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INTRODUCTION TO MULTISENSOR RECONNAISSANCE

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This document presents a comprehensive, but practical introduction to multisensor usage in aerial reconnaissance. It covers primarily the current and conceptual multisensors operating in electro-optical and microwave regions of the electromagnetic spectrum, the various types of aerial reconnaissance/surveillance missions, and the factors to be considered in utilizing these sensors for such missions. The document also includes a bibliography and an extensive glossary to cover all reconnaissance-oriented nomenclature.

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INTRODUCTION TO MULTISENSOR RECONNAISSANCE

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HORACE H. VALVERDE

FOREWORD

This report represents part of the work performed under Contract F33615-69-C-1821, "Multisensor Operator Training." This contract was sponsored by the RSA-665A Advance Development Program Office, AF Avionics Laboratory, AF Systems Command, Wright-Patterson Air Force Base, Ohio. The technical effort was monitored by the AF Human Resources Laboratory (AFHRL) and the Directorate of Reconnaissance Engineering, AF Systems Command, Wright-Patterson AFB, Ohio. Mr. Richard J. Jennewine (AFAL/RSA-665A) was the task manager, and Mr. Horace H. Valverde (AFHRL/TRT) was the project engineer.

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This report has been reviewed and is approved.

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ABSTRACT

The significance of this document is to provide Air Force trainees involved in photo interpretation work and sensor operation with the basic knowledge and understanding of reconnaissance sensors and various other aspects of reconnaissance. It covers primarily the current and conceptual multisensors operating in electro-optical and microwave regions of the electro-magnetic spectrum, the various types of aerial reconnaissance/surveillance missions, and the factors to be considered in utilizing these sensors for such missions. The document also includes a bibliography and an extensive glossary to cover all reconnaissance-oriented nomenclature.

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LIST OF ILLUSTRATIONS

LIST OF SYMBOLS

A	Ground-area coverage
c	Speed of light
D	Aperture diameter
d	Image distance
d_1	Longitudinal image distance
d_2	Lateral image distance
F	Focal length
f	Frequency
H	Absolute altitude
L	Ground distance
L_1	Longitudinal ground distance
L_2	Lateral ground distance
N	TV resolution (lines per millimeter)
R	Optical resolution (line pairs per millimeter)
S	Slant range (along optical axis)
S_f	Slant range to far edge of ground coverage
S_n	Slant range to near edge of ground coverage
S_d	Displayed slant range
T	Time
V	Ground velocity of aircraft
λ	Wavelength of electromagnetic energy
ϕ	Tilt angle (optical)
ϕ_f	Tilt angle to far edge of ground coverage
ϕ_n	Tilt angle to near edge of ground coverage

LIST OF SYMBOLS - Concluded

ϕ_1 & ϕ_2	Off optical axis angles within sensor field of view
θ	Field of view
$\Delta\theta_d$	Diffraction limiting resolution
$\Delta\theta$	Instantaneous field of view
$\Delta\theta_1$	Longitudinal instantaneous field of view
$\Delta\theta_2$	Lateral instantaneous field of view

SECTION I

INTRODUCTION

SCOPE

Numerous documents have been published on the various aspects of multisensors and their applications in aerial reconnaissance missions. However, each generally offers a specific treatment or an in-depth analysis of a particular aspect. Accordingly, this document is intended to serve as a comprehensive, but practical, introduction to multisensor aerial reconnaissance.

DEFINITION

Multisensor aerial reconnaissance or surveillance may be simply defined as the use of an airborne platform with two or more sensing devices to detect and record reflected and/or emitted energy from remote terrestrial targets and backgrounds. Normally these sensors operate in different bands of the electromagnetic (EM) spectrum.

BACKGROUND

Most of the major developments in aerial reconnaissance have occurred during wartime. From ancient times, when spies investigated the enemy's strength, to current complex multisensor operations, reconnaissance has become increasingly important to military operations. Aerial reconnaissance was first practiced during the Battle of Fleurus in 1794 when the French used a balloon to observe the movement of Austrian troops. During the Civil War, manned balloons, usually at 200-foot altitudes, were used to observe entire battlefields. For example, John La Mountain made a series of free ascents to spy on Confederate forces to the west of the Union forces at Cloud's Mill, Virginia. The effectiveness of these observations forced Beauregard, the Confederate Commander, to camouflage his troops and equipment. Although the camera was available during the Civil War, all evidence indicates that no military aerial photographs were taken by either side.

On June 1898, ill-equipped and inexperienced American crews performed the first balloon reconnaissance mission of the Spanish-American War by confirming the presence of the Spanish fleet in the harbor of Santiago, Cuba. The next day, American balloonists contributed to the U.S. victory at the Battle of San Juan Hill by directing artillery fire and by discovering an additional approach route for American forces.

During the early 1900's, George Lawrence, an American balloon photographer, devised various cameras weighing more than 1,000 pounds which were capable of taking pictures approximately 8 by 4 feet. He raised the cameras by means of balloon kites and associated apparatus to heights of several thousand feet. In 1906, he hoisted a huge camera 2,000 feet over San Francisco and obtained an 8- by 4-1/2-foot photograph of the great earthquake and fire.

In 1909, Wilbur Wright took the first known photographs from an airplane over Centocelle, Italy. In 1911, Lieutenant John Walker successfully photographed a civilian flying field in San Francisco from an airplane at an altitude of 1,200 feet.

Photographic reconnaissance was used extensively by both sides during World War I. Great advances were made in camera design and photographic techniques as well as in photographic interpretation. During 1918, the Germans used [illegible],000 mapping cameras and 100 automatic film cameras for large-size pictures and took an average of 4,000 photographs daily. Photographic sections of the American Expeditionary Force produced over one million prints during the period from 1 July to 11 November 1918. Photographs were processed so efficiently that often only 20 minutes elapsed between the taking of the photograph and the delivery of the resulting intelligence to American batteries.

Faster aircraft and refined aerial reconnaissance cameras were developed during World War II. One of the greatest achievements of aerial reconnaissance was the detection and interpretation of the German V-1 missile launching sites and later the V-2 missile launching sites by using aerial photography.

Reconnaissance multisensors have been developed principally since World War II. Such sensors detect reflected and emitted radiation from various wavelength ranges in the electromagnetic spectrum as well as visible energy. Since each range in the spectrum produces unique target information, multisensors with various wavelength sensitivities yield a more complete picture of the target. Moreover, current reconnaissance systems permit sensing remote targets at night and to some extent during inclement weather.

In summary, this document treats primarily of multisensors operating in the electro-optical and microwave portions of the electromagnetic spectrum, of the various types of aerial reconnaissance/surveillance missions, and of the factors to be considered in utilizing these sensors for such missions.

SECTION II

ELECTROMAGNETIC SPECTRUM

The electromagnetic (EM) spectrum is the entire range of wavelengths or frequencies of electromagnetic radiation extending from cosmic rays through the longest radio waves. Current multisensors operate in the electro-optical and microwave portions of the EM spectrum. Figure 1 shows the wavelength for each type of electromagnetic radiation in the entire EM spectrum. The frequency of the radiation for each of these types may be computed by the following equation:

$$f = \frac{c}{\lambda}$$

where

f = frequency in Hertz (cycles per second)
c = speed of light in meters per second (3.0×10^8)
λ = wavelength of the EM radiation in meters

Radiations with wavelengths above 1 millimeter (the border between microwave and infrared radiation) are commonly given in terms of frequency; and those below, in terms of wavelength.

ELECTRO-OPTICAL AND MICROWAVE RADIATION

Electro-optical Radiation

The electro-optical portion of the spectrum includes ultraviolet, visible, and infrared light whose wavelengths lie between 10^{-10} and 10^{-3} meter. The microwave region, where radar operates, covers wavelengths from 10^{-3} to 1 meter.

Ultraviolet

The ultraviolet region of the EM spectrum includes radiation with wavelengths between 10 and 400 nanometers (nm). This region is broken down into three ultraviolet groups: near (300 to 400 nm), far (200 to 300 nm), and extreme (10 to 200 nm). The range for the last group overlaps with the range for X-rays. The ultraviolet region has not been used extensively in operational military sensor systems since the radiation reaching the sensor after passing along an appreciable path length (distance from object to sensor) is reduced to very small levels by atmospheric attenuation.

Visible

The visible region of the EM spectrum is the area in which the human eye responds. This includes wavelengths between

400 nm (violet) and 700 nm (red). The spectral colors from the shortest to the longest wavelengths are violet, blue, green, yellow, orange, and red. The primary sensor systems operating in the visible region are aerial cameras using aerial film (some photographic films extend into the near ultraviolet and near infrared portions of the spectrum between 700 and 900 nm), television (TV) systems, and some laser line scanners.

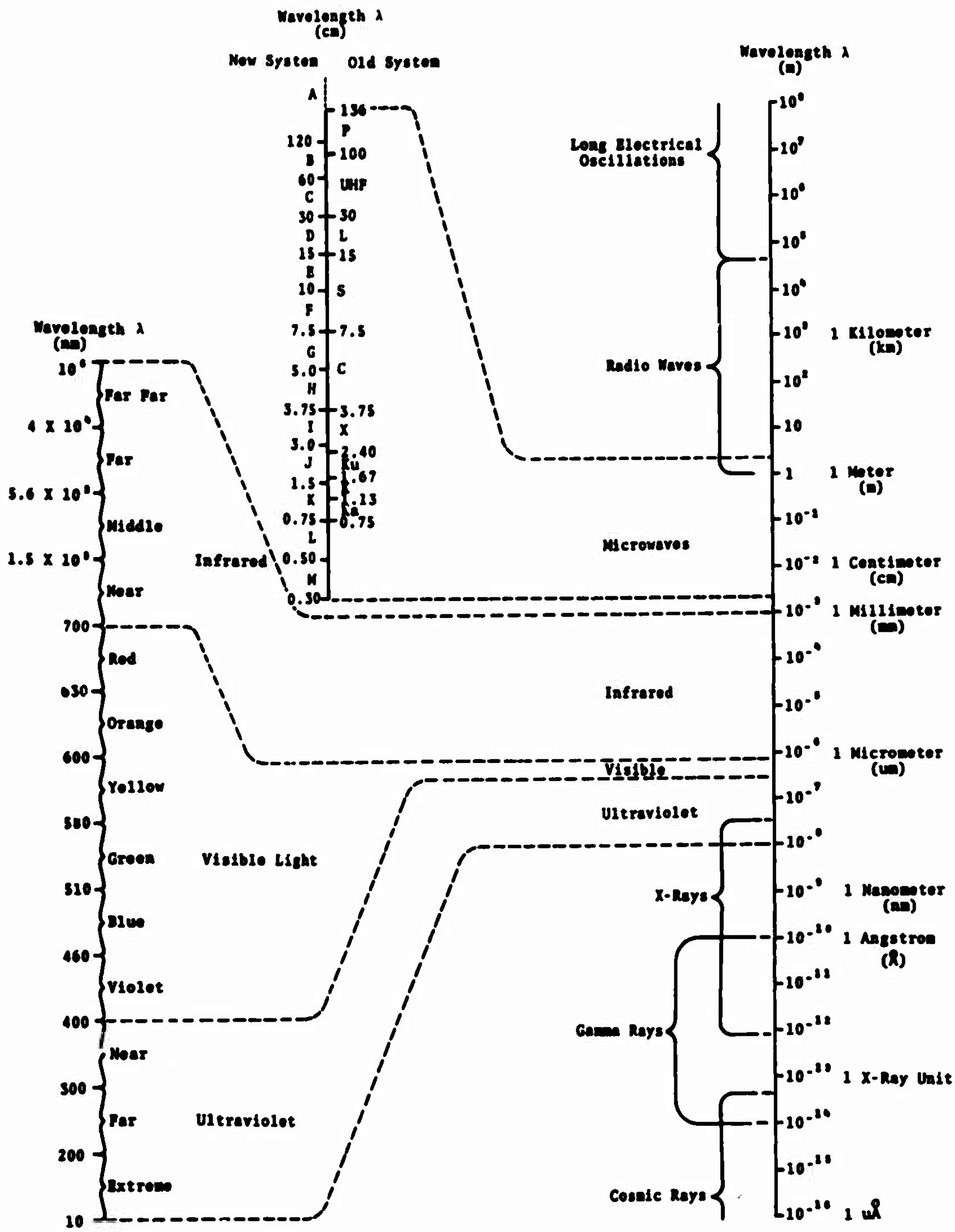


Figure 1. The Electromagnetic Spectrum

Infrared

The infrared (IR) region of the EM spectrum includes wavelengths between 0.70 and 1000 μm (one millimeter). This region is broken down into four infrared groups: near (0.70 to 1.5 μm), middle or intermediate (1.5 to 5.6 μm), far (5.6 to 40 μm) and far-far (40 to 1000 μm). Sometimes the latter two groups (far and far-far) are combined and simply called the far IR. Although the human eye cannot see IR radiation, the body can sense it through the skin since this radiation is easily converted into heat. Since most objects (at all earth ambient temperatures) emit a peak radiation in the 8- to 14-μm region (far IR), sensors have been developed with a high sensitivity in this spectral region. The primary sensors operating in the infrared region include infrared raster and line scanners, and some laser line scanners.

Microwave Radiation

The microwave region of the EM spectrum includes wavelengths from 1 millimeter (mm) to 1 meter (m). Microwaves are broken down into twelve frequency bands:

(1)	B-Band:	250	to	500	MHz	(120 to 60 cm)
(2)	C-Band:	500	to	1,000	MHz	(60 to 30 cm)
(3)	D-Band:	1,000	to	2,000	MHz	(30 to 15 cm)
(4)	E-Band:	2,000	to	3,000	MHz	(15 to 10 cm)
(5)	F-Band:	3,000	to	4,000	MHz	(10 to 7.5 cm)
(6)	G-Band:	4,000	to	6,000	MHz	(7.5 to 5.0 cm)
(7)	H-Band:	6,000	to	8,000	MHz	(5.0 to 3.75 cm)
(8)	I-Band:	8,000	to	10,000	MHz	(3.75 to 3.0 cm)
(9)	J-Band:	10,000	to	20,000	MHz	(3.0 to 1.5 cm)
(10)	K-Band:	20,000	to	40,000	MHz	(1.5 to 0.75 cm)
(11)	L-Band:	40,000	to	60,000	MHz	(0.75 to 0.50 cm)
(12)	M-Band:	60,000	to	100,000	MHz	(0.50 to 0.30 cm)

A portion of a thirteenth band, the A-Band, is sometimes included because radar is occasionally used at some of the higher frequencies within this band; technically, however, it belongs in the radio wave region of the spectrum. The A-Band has frequencies between >0 and 250 MHz (<∞ to 120 centimeters). Included in Figure 1 is a list of the old designations for microwave bands as well as the new ones since they are still widely used. Generally speaking, the longer the wavelength, the greater the penetration of a radar signal through both the atmosphere and the vegetation. However, the longer the wavelength, the more difficult it is to produce a given ground resolution.

REFLECTED AND EMITTED RADIATION

Energy from targets and backgrounds is primarily either reflected or emitted radiation.

Reflected Energy

Reflected energy is that portion of energy from a radiant source which is reflected from a surface to a sensor. For example, a flashlight in a totally dark room is the radiant source, the light reflected from the various surfaces is the reflected energy, and the human eye is the sensor. The reflected light enables the viewer to discern the apparent color, size, shape, identification, and location of the illuminated objects.

Emitted Energy

Emitted energy is generated by all objects whose temperature is above absolute zero (0° Kelvin or -459.67° Fahrenheit). The peak output of this energy depends upon the absolute temperature of the object. For most objects (whose temperatures range from 0° to 100°F), the peak energy output is in the 8- to 14-μm region (far IR) of the EM spectrum. As the temperature of an object increases, the peak of its emitted energy shifts to shorter wavelengths. When temperatures reach thousands of degrees F, the human eye can detect a portion of the emitted energy. For example, the peak energy from a tungsten filament in a lighted bulb is visible since the filament temperature is about 4500°F; similarly, the energy emitted by liquid steel poured from an open hearth furnace is visible since there is sufficient energy emitted in the visible portion of the electromagnetic spectrum, although the peak of the energy is in the middle IR portion of the spectrum (approximately at 2 μm). Figure 2 shows the spectral radiance as a function of the wavelength of the energy for blackbodies (objects which are perfect emitters) between 200° and 6000°K.

ILLUMINATION SOURCES

There are two basic types of energy sources: natural and man-made. The multisensors in aerial reconnaissance make use of both types.

Natural Illumination Sources

Sun

The most frequently used source of illumination in the visible portion of the spectrum is the sun. At the earth's surface, the sun's illumination varies by hour, season, and latitude. The sun illumination of observed targets varies according to atmospheric

elements in the path between the source and target and between the target and sensor. Figure 3 shows the energy distribution of the sun from 0.3 to 4.6 μm (the near ultraviolet to the middle infrared). The peak output is the visible portion of the EM spectrum and occurs at about 0.5 μm (green light). Figure 4 shows the illumination of the sun for various solar altitudes. The solar altitude is the angle subtended by the horizon to the observer and from the observer to the sun; thus the "higher" the sun in the sky, the greater the solar altitude.

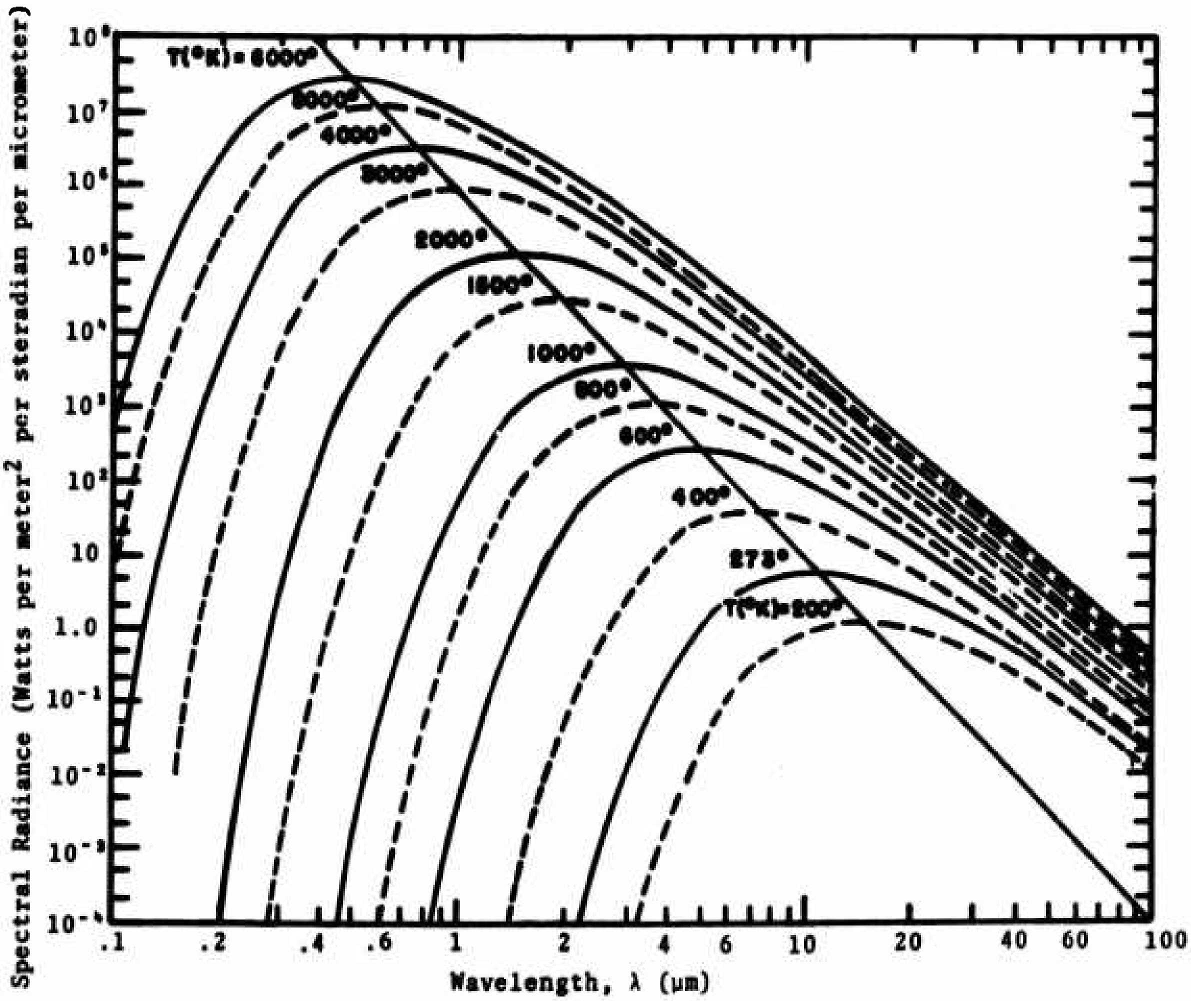


Figure 2. Spectral Radiance of Blackbodies Whose Temperature Ranges from 200° to 6000°K

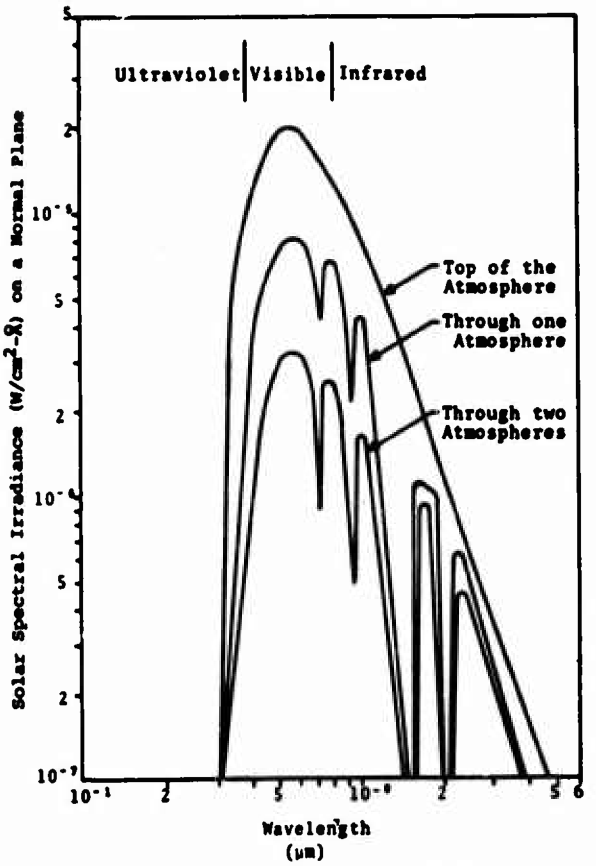


Figure 3. Solar Spectral Irradiance on a Plane Normal to the Sun's Rays

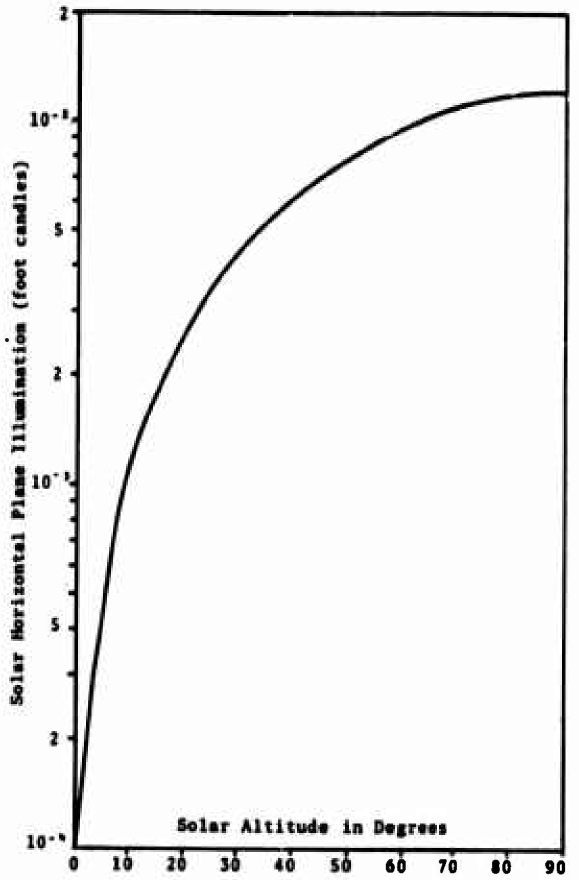


Figure 4. Solar Horizontal Plane Illumination Versus Solar Altitude

Moon

The moon is the brightest natural illumination source in the visible portion of the EM spectrum at night. Several sensors, such as low-light-level television (LLLTV), use it as a light source. However, it is not a reliable source since (1) its phase changes in a 28-day cycle, (2) it rises about 50 minutes later each day, and (3) clouds may block its light path. Figure 5 shows the relative illumination of the reflected sunlight as a function of phase. The illumination of a waxing moon increases day by day as the moon phase changes from a new to a full moon; conversely, the illumination of a waning moon decreases as the moon phase changes from a full to a new moon. The moon not only reflects the light of the sun, but also emits energy as any object with a temperature above absolute zero. Although the moon's peak emitted energy is slightly greater than its reflected sunlight energy at the top of the atmosphere (as shown in Figure 6), the emitted energy is negligible at the earth's surface because the earth's atmosphere absorbs most of this energy in the 5- to 8- μm region. Moreover, other illumination sources emit more energy at the middle and far IR region than the moon.

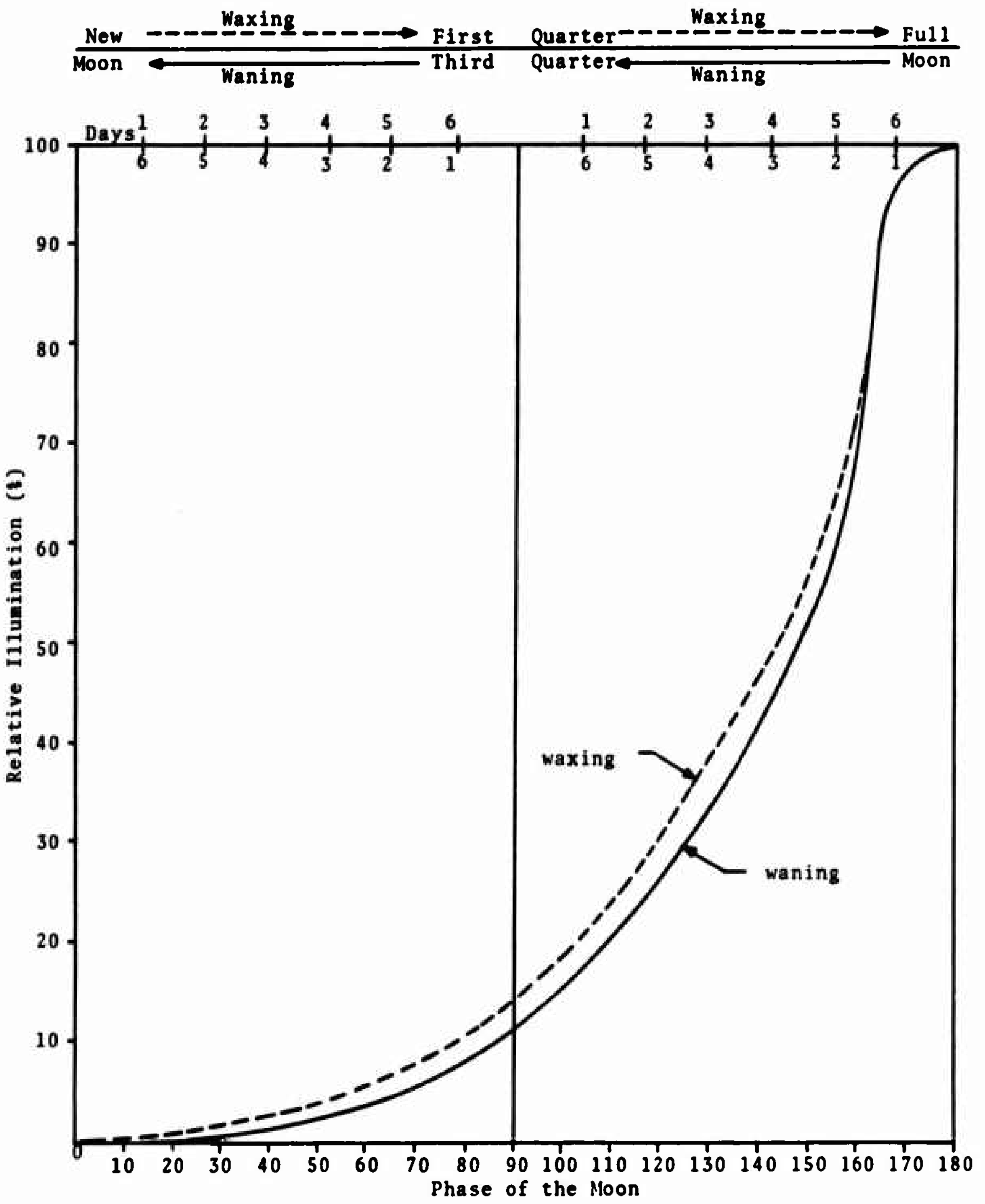


Figure 5. Moonlight Illumination as a Function of Phase

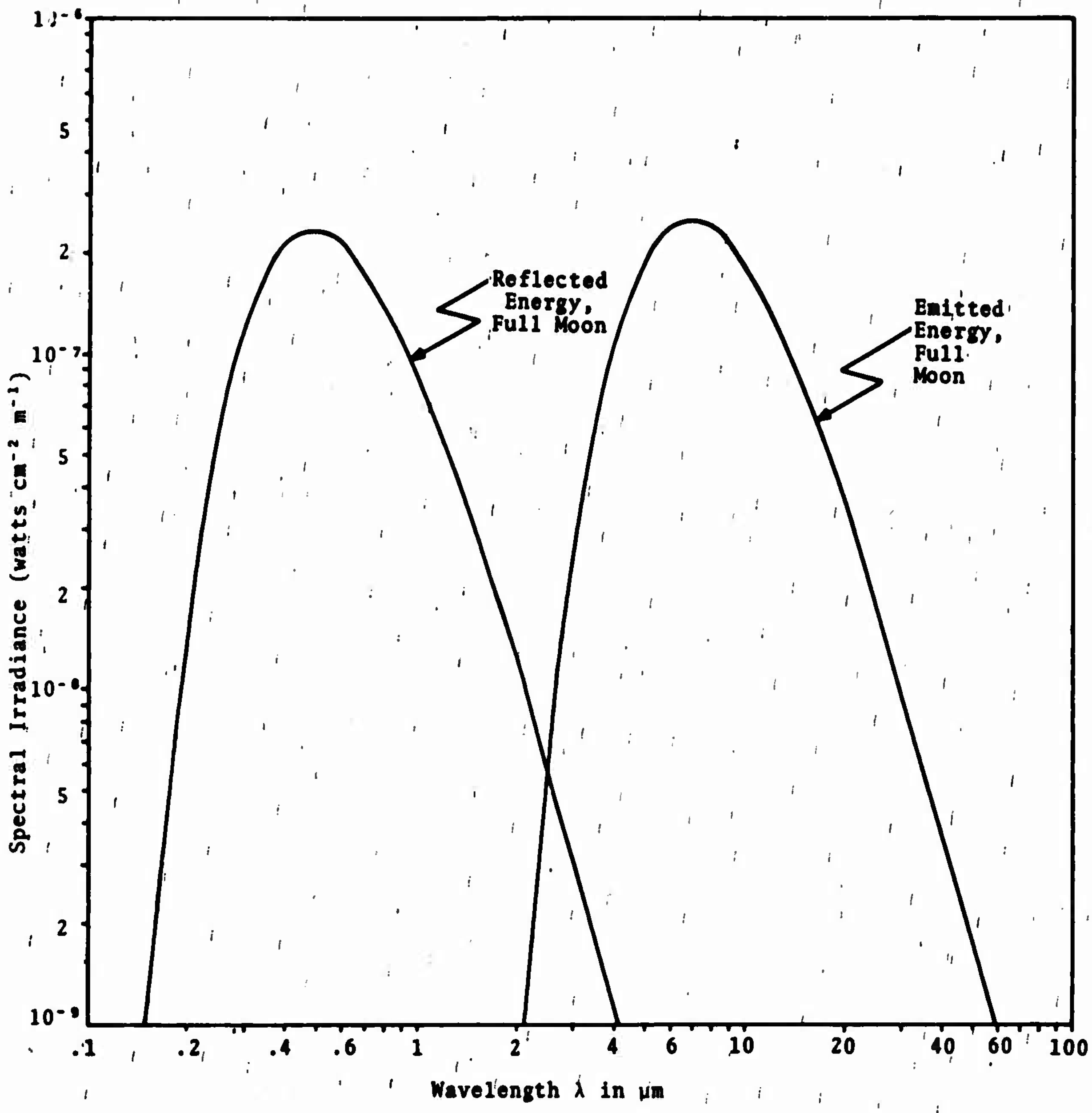


Figure 6. Calculated Spectral Irradiance of the Moon at the Top of the Atmosphere

Starlight, Airglow, and Tropospheric Thermal Radiation

Although the moon is the primary source of energy in the visible portion of the spectrum at night, both starlight and airglow contribute to the energy received on the earth's surface, particularly during clear moonless nights. Airglow consists of emissions from atomic sodium and oxygen, molecular oxygen, hydroxyl ions, and the green continuum, all existing high in the earth's atmosphere, above 70 kilometers (km). The peak emissions occur

in the 90- to 120-kilometer region. The green continuum is the prime source of illumination in the night sky between 0.50 and 0.65 micrometers (μm), that is, in the green through the near-red portions of the visible spectrum. The hydroxyl ions account for most of the illumination attributed to airglow. They emit in 45 separate bands ranging from 0.38 to 4.5 μm, and are the principal contributors to the brightness of the night sky over the interval from 0.75 to 2.5 μm. Although the moon and starlight reach their highest illumination levels at 0.5 μm, airglow peaks at 1.6 μm (near IR). Another important contributor to night illumination is tropospheric thermal radiation. This radiation is the prime illumination source in the IR region, starting from 2.0 μm in summer (2.5 μm in winter) for mid latitudes, and peaks in the 8- to 14-μm region. However, since most energy sensed by IR sensors is emitted, not reflected, by the targets and backgrounds at wavelengths between 2.5 and 4.0 μm and longer, the tropospheric radiation is not a particularly useful illumination source. Figure 7 shows the relative intensity of illumination of airglow, full moon, and tropospheric thermal radiation.

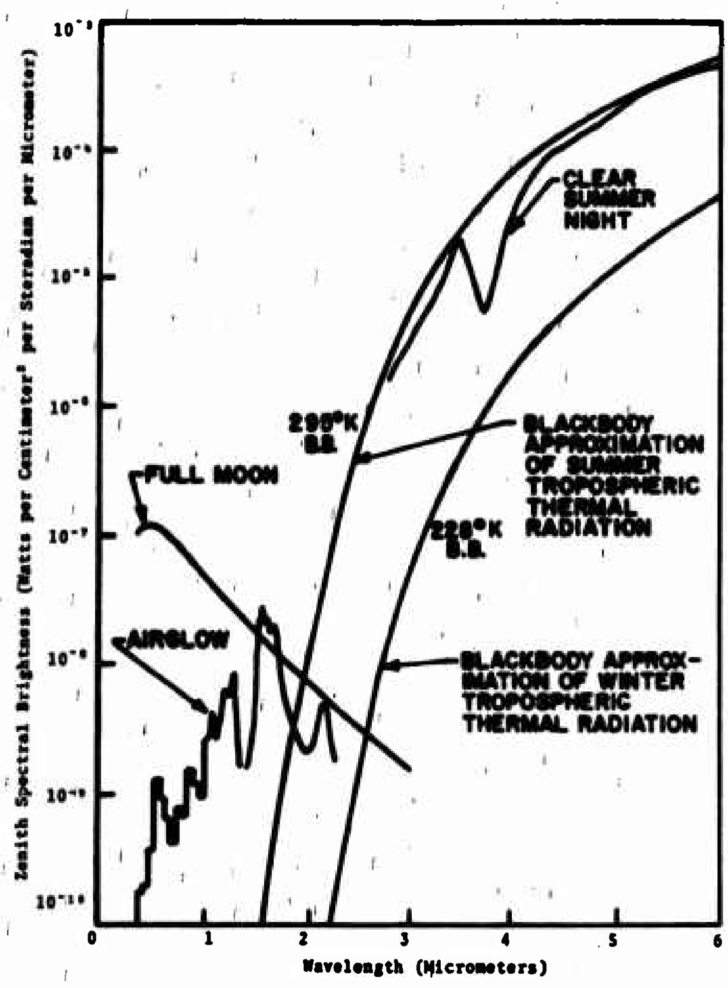


Figure 7. Zenith Spectral Brightness of the Night Sky, 0.4 to 6.0 μm.

Man-Made Illumination Sources

There are several man-made illumination sources which emit energy in the visible through the microwave region of the EM spectrum.

Pyrotechnic Devices

These devices are one-time flash units and produce visible light by a chemical action similar to that in fireworks. Pyrotechnic devices come in two general sizes - small and large, respectively called photoflash cartridges and bombs. These illumination devices are used with aerial cameras at night. The cartridges are used at low altitudes (up to 8000 feet), and the bombs are used for medium altitudes (up to 20,000 feet).

Flasher Units

These devices are generally used in the same way as pyrotechnic devices; however, they have the advantage of repeated usage. The flasher is usually used up to altitudes of 1500 feet.

Lasers

Lasers are used as illumination sources in both the visible and the infrared regions of the EM spectrum. They are primarily used in line-scan sensor systems.

Radars

In the use of radar as an illumination source, an antenna radiates pulses of microwave energy which travel through space, strike the target, and reflect a portion of the energy back to the radar receiver.

SECTION III

RECORDED RADIATION CHARACTERISTICS OF TARGETS AND BACKGROUNDS

The recorded and subsequently displayed sensor information is in a two-dimensional form. This information may be presented in a format of (1) a square, as in a photograph from aerial cameras or TV systems; (2) a rectangle or strip, as in imagery of line scan sensors; or (3) a circle, as in imagery of a PPI (plan position indicator) radar scope. Whatever the format, the displayed information contains backgrounds and possibly targets. Targets, as used here, refer to man-made items or natural objects of interest, and backgrounds refer to natural materials which are not of interest. Some of the clues which help the observer to distinguish between targets and backgrounds are discussed below.

SHAPE

The shape of an object is the spatial form or configuration of the object. Targets, or man-made objects, are usually symmetrical in shape and have straight lines and/or regular geometric patterns. When viewed from the air in a vertical position, or plan view, most man-made targets have an outline which is either rectangular or circular. One of the most common methods of hiding an object is to break up its shape by covering it with natural objects such as vegetation. Background objects, such as natural vegetation, have irregular shapes.

SHADE OR TONE

The reflected or the emitted energy from different targets and backgrounds vary in intensity. Consequently, the sensor detects energies of various intensities and records them as various levels or shades of gray. These shades are essential in discerning a target and determining its relationship to the background. The more shades that a sensor can reproduce, the easier the observer can distinguish between different objects. Imagery from cameras, that is, film, normally exhibits up to 21 discernible shades of gray on photographic film, whereas imagery from present line and raster scanners have about 8 to 12 distinct shades. These shades are relative to each other and not absolute shades. Moreover, the same object, such as a roof, may have different shades of gray in successive viewings. There are many variables which affect the actual tone displayed. Some of these are the gain of the sensor system, the spectral characteristics and intensity of the illumination source, the atmospheric attenuation, the processing of the sensor information, and the humidity and temperature differences between the targets and the backgrounds. The difference between the shades of two objects, or an object and a background, is called contrast.

Obviously, when the contrast is high, it is easier to distinguish between the two objects.

SIZE AND SCALE

The size of the object relates to the dimensions of the object. Sometimes the absolute size is not required as a clue to the identification of the object. For example, if a 2-1/2-ton cargo truck has been identified, the relative size of a nearby object can be determined by comparing it with the truck. Scale is used to determine the sizes of objects and the distances between them. The scale of the imagery is a ratio of the image size to the object size. For example, if the object in the image is 0.01 feet long and the object on the ground is 10 feet long, then the scale is 1:1000. When the scale of the imagery is known, the size of the target may be determined by multiplying the image size by the scale factor. The scale factor is the reciprocal of the scale; for example, the scale of 1:1000, or 1/1000, has a scale factor of 1000.

SHADOW

If a shadow is cast across an area photographed in daylight, some shades of gray may still be found in the shadowed area since it is illuminated by the sky as well as by the sun. If the illumination source is man-made, however, the information in a shadowed region is lost and cannot be identified. Shadows can be clues to interpretation since they present profiles of the side view; for example, although a bridge itself may be readily identified as such in the imagery, its profile might enable the observer to identify the exact type of bridge, for example, a truss-through bridge with three spans.

SURROUNDING OBJECTS AND PATTERNS

Surrounding objects may give clues to the identification of a particular object. For example, a van found in the center of a 57mm Antiaircraft Artillery (AAA) site most probably would be a fire-direction center (radar) for control of the AAA battery because of the reasonable association of such a van in this installation. Other examples of readily identifying the type and function of man-related targets by their environs would be a path between a village and a rice paddy, and a track passing through rough terrain and vegetation and connecting storage dumps. Many targets, however, have such subtle environmental associations that the multisensor operator must have an in-depth knowledge of the area geography and culture.

SECTION IV

TYPES AND CLASSIFICATIONS OF SENSOR SYSTEMS

There are many types of remote sensors. Some lend themselves to airborne uses more readily than others. Although electro-optical and microwave sensors are the primary airborne sensors, other types are also discussed in this section.

EFFLUENT SENSORS

Effluent sensors detect odors given off by a chemically active object. These detectors are primarily employed to detect vehicles and men. Typical deployment of these sensors would be to tether them behind low-altitude, slow-flying aircraft or to "seed" them (scattered placement) along likely avenues of approach or lines of communication (LOC's) where enemy activity will most likely occur. In the latter deployment, radio communication links are required to relay the sensor information.

SEISMIC SENSORS

Seismic sensors detect shock waves traveling along the ground. Although their primary use is to detect vehicles, some sensors are sensitive enough to detect a man walking. However, such extraneous activity as animal movement may generate false information. These sensors are normally seeded from an aircraft similar to the seeding of the effluent sensors.

ACOUSTIC SENSORS

Acoustic sensors detect sound waves and are used as seismic sensors to monitor both troop and vehicular traffic. They can be seeded from aircraft or planted along lines of communication.

MAGNETIC SENSORS

Magnetic sensors are used to detect electronic equipment and vehicles. These sensors detect changes in the earth's magnetic field due to the presence of operating electronic equipment and/or iron or steel. These sensors are also normally seeded from aircraft or planted along lines of communication.

IGNITION SENSORS

Ignition sensors are used to detect broadband electromagnetic radiation caused by the spark in the ignition system of an internal

combustion engine. Their primary use in airborne installations is detecting moving vehicles along supply routes.

ELECTRO-OPTICAL AND MICROWAVE SENSORS

The most frequently used remote sensors are the electro-optical and microwave sensors. Both types detect reflected and emitted radiation; the electro-optical sensors operate from the ultraviolet through the infrared (1×10^{-10} through 1×10^{-3} meter) portion of the electromagnetic spectrum, and the microwave sensors operate from the infrared to wavelengths of about one meter.

CLASSIFICATION

Of the several ways of classifying these sensors, two are usually sufficient: (1) the spectral region in which the sensor operates and (2) the primary source of the illuminating energy. Other considerations such as attitude, field of view, focal length, and format are used for mission planning and do not affect the actual classification of the sensor.

Spectral Region

The spectral region is the wavelength or frequency range where the sensor responds. For example, the spectral region for a camera would be the range where the photographic film responds. At present most aerial films respond in the range from 0.4 to 0.7 μm (the visible portion of the EM spectrum), but some are responsive to 0.9 μm (near IR). Infrared sensors operate in the 3- to 5-μm and/or the 8- to 14-μm region.

Source of Energy

The source of energy is important since the sensor may be either an active or a passive system. An active system requires man-made illumination, whereas a passive system uses natural reflected or emitted radiation. For example, daytime aerial photography is a passive system, and nightime aerial photography which must use either a pyrotechnic or a flasher type of device is an active sensor system. In addition, an active system can have either a covert or an overt illumination source. Normally a covert illumination source radiates in a spectral band outside the visible region, and an overt source radiates energy within the visible portion of the EM spectrum. An infrared laser line scanner is an example of an active covert sensor system; and a nighttime camera using pyrotechnic or flasher devices is an example of an active overt sensor system.

Specific Types of Electro-Optical, Microwave, and Direct-Viewing Devices

The following paragraphs deal with the fundamental characteristics of the electro-optical and microwave sensors and their prime advantages and disadvantages.

Aerial Cameras

Aerial cameras have been used far more extensively for reconnaissance than any other type of remote sensor. The camera has the highest resolution and normally the least amount of distortion. It is the sensor most used as a mapping instrument, although Side Looking Radar (SLR) has been used with some success. Generally speaking, the aerial camera is very versatile, and some types can operate with both natural and artificial lighting. Frame-type cameras are designed to operate at cycling rates ranging from less than one cycle per second to more than six cycles (frames) per second. Shutter speeds range from 1/30 to 1/4000 second, and focal lengths vary from 1.5 to 240 inches. Standard film sizes are widths of 70 mm, 5 inches, and 9-1/2 inches with lengths from 250 to 1200 feet.

Cameras are primarily used during daylight. Since lighting conditions vary with time of day and cloud cover, an automatic exposure control (AEC) is used to set the aperture and shutter speed. Night photography is taken with the aid of artifical illumination devices, either pyrotechnic cartridges or bombs, or flasher units. Overt light sources are most always used in low-threat or permissive environments. Photoflash detectors sense the reflected light from the terrain and activate the camera shutter at the peak illumination level.

Military aerial cameras are designated by two letters and usually one to three numbers. The first letter is K, which means camera, although the letter C also has been used as the first letter. The second letter is usually A, B, C, or S and designates the type of camera: A for reconnaissance camera, B for strike camera, and C for mapping camera. The letter S represents the set or system, and the camera itself may be any one of the three types (recon, strike, or mapping). The numbers are associated with a specific model and are generally assigned according to the chronological order of the development and operational start of each model unit. The letter T, used by itself, represents a mapping camera introduced before the current designating system was originated, for example, the T-11. Newer mapping cameras, such as the KC-1B, reflect the current designation. In this example, the B stands for the second modification to the basic camera (KC-1).

There are three basic types of aerial cameras: frame, panoramic, and strip.

1. Frame Cameras

Framing cameras are the most common type of aerial cameras. The format for framing cameras is generally 4-1/2 by 4-1/2 inches, whereas that for mapping cameras is primarily 9 by 9 inches. Since framing cameras record an entire frame instantaneously, they reproduce the ground scene with nearly perfect geometric fidelity as viewed from a particular aspect angle. Four basic types of film are used in aerial cameras: black and white (panchromatic), black-and-white IR, color, and false color (color IR or camouflage detection). Generally, the faster the film, the poorer the resolution; and the slower the film, the higher the resolution. The faster films are used at low altitudes and fast aircraft speeds and under poor lighting conditions; whereas the slower, but higher resolution, films are used at high altitudes and under good lighting conditions. Figure 8 is an example of panchromatic photography taken by a frame camera in the forward-looking position. Black-and-white IR film is also frequently used. Figure 9 is an example of this type of imagery. Notice that the vegetation in the IR imagery of Figure 9 is very light in tone in the near IR compared with that in the panchromatic (visible) imagery of Figure 8. Although water is not shown in Figure 9, it will appear dark on positive IR imagery. A photograph of a typical aerial reconnaissance camera is shown in Figure 10.

2. Panoramic Cameras

Panoramic, or pan for short, cameras use moving lenses or rotating mirrors or prisms to sweep the image onto the film. Usually mounted in the vertical position, these cameras sweep the image perpendicular to the line of flight. This camera type has the prime advantage of covering wide swaths in one pass. Focal lengths usually vary between 3 and 24 inches, with 3 and 12 inches being the most common. Films of 5-inch and 70-mm widths are used, the 5-inch width being the most common. Angular fields of view vary between 90 and 180 degrees (the 180-degree view extends from horizon to horizon). Formats vary from 2-1/4 by 8-1/4 inches to 4-1/2 by 29 inches. Figure 11 is an example of 180-degree pan imagery. Note that the horizon is shown at both ends of the imagery and that the perspective changes from vertical to oblique angles toward the ends. Also, the scale decreases from the center toward the edges. This inherent characteristic of changing scale and aspect angle detracts from its other qualities, particularly in the target-location aspect of reconnaissance. Figure 12 shows a typical aerial pan camera.

Figure 8. Panchromatic Photography from a Forward-Looking Frame Camera

Figure 9. Black & White IR Photography from a Frame Camera in the Vertical Position

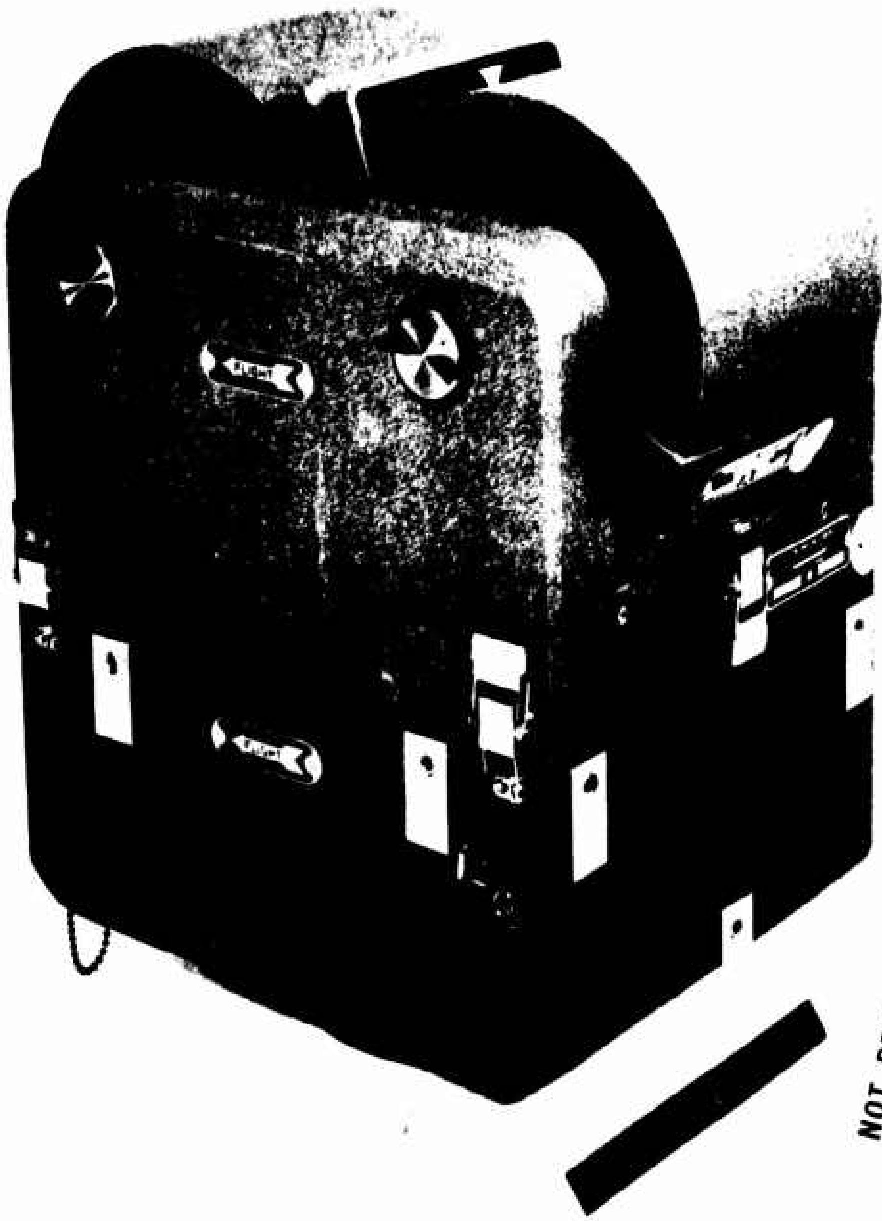


Figure 10. An Aerial Reconnaissance Framing Camera

Figure 11

Panchromatic Photography from a Downward-Looking 180 Degree Panoramic Camera

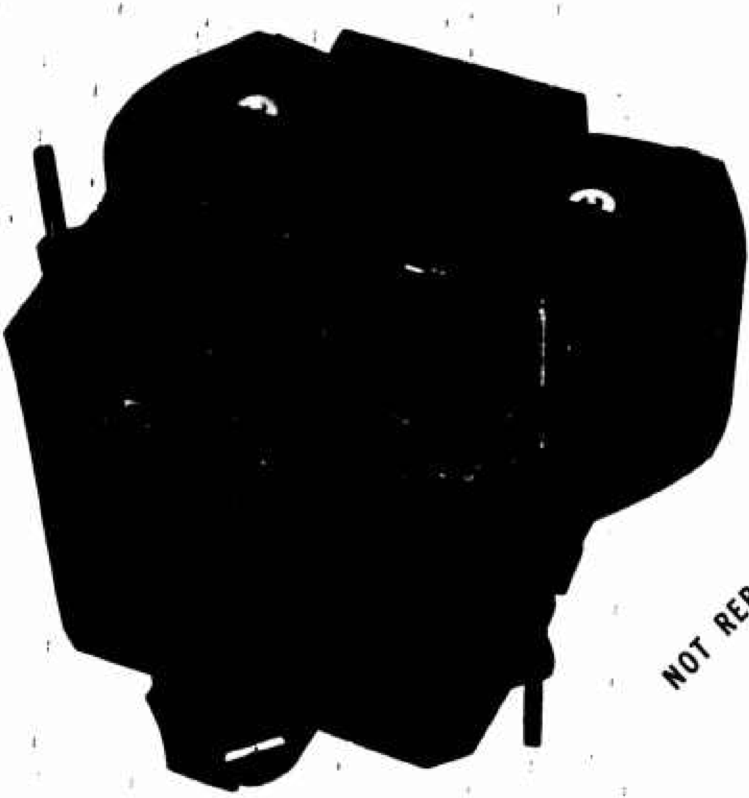


Figure 12. An Aerial Reconnaissance Panoramic Camera

3. Strip Cameras

Strip cameras produce the film image by pulling the film past a variable-width slit. The width of the slit is varied as the ratio of the aircraft velocity to absolute altitude, commonly expressed as the V over H (or V/H). The exposure is controlled by the AEC which varies the width of the shutter slit not only as a function of V/H but as a function of the ambient illumination. Because the imagery in the direction of flight depends on the movement of the aircraft, only a small width is exposed at any given time. To ensure that aircraft roll and pitch do not change the geometry of the imagery, a stabilized mount is highly desirable. In addition, the aircraft must fly at a constant altitude and along a given azimuth to provide a constant scale in both film directions. Figure 13 shows a typical aerial strip camera.

Raster Scanners

Raster scanners scan an image format in a relatively short period of time. In the scanning process, the pattern varies in both type and geometry. Scanners are basically either electronic or mechanical devices. Raster scanners have the advantage of being real-time sensors. The information acquired by raster scanners can

be recorded on film or displayed on a CRT, or both. The major disadvantage of these sensors is that their resolution is not as good as that produced by aerial cameras. Depending upon the type, these sensors can be used during both day and night reconnaissance missions. There are two types of raster scanners, TV and IR. Some TV systems are designed for use during day operations, while others are designed for use during night operations. IR raster scanners may be used for both day and night operations.

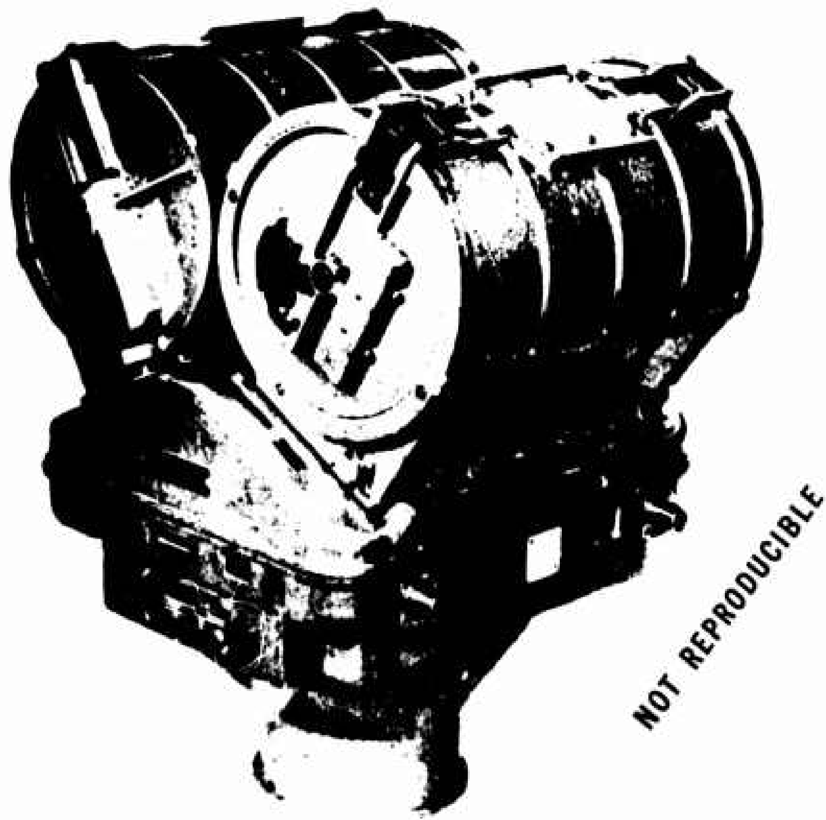
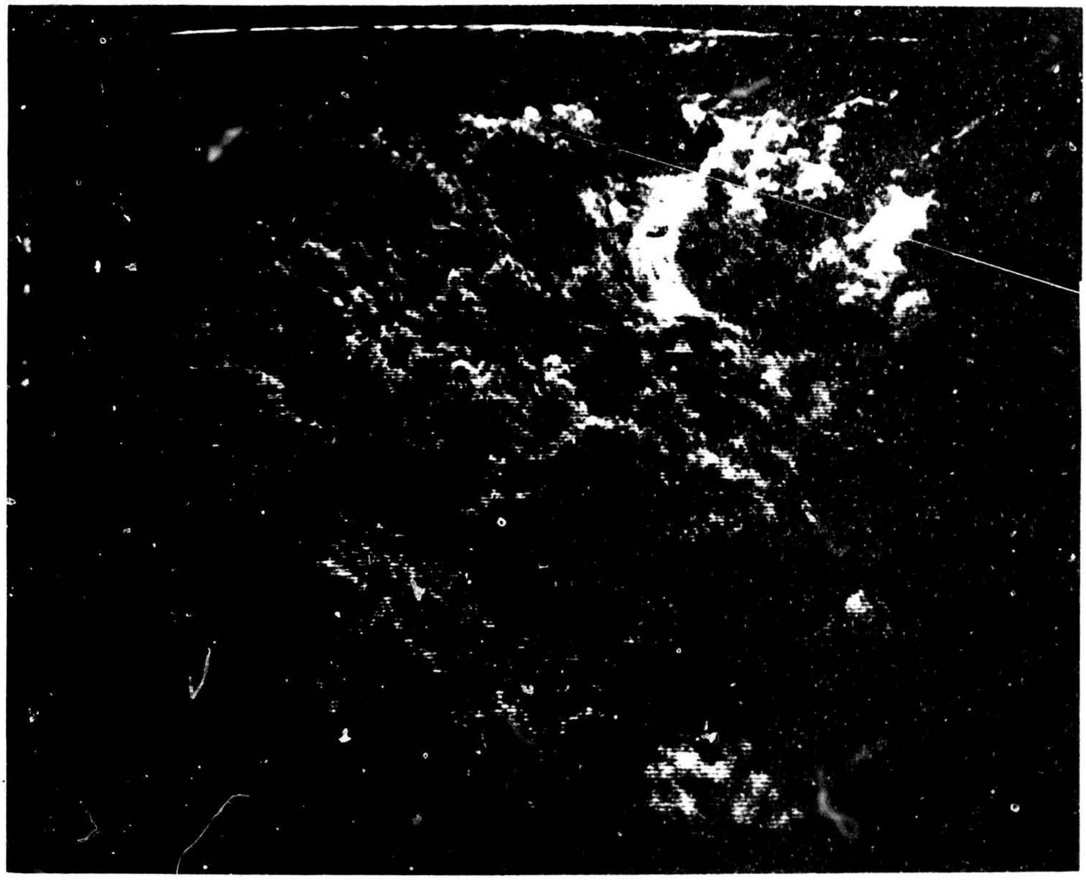


Figure 13. An Aerial Reconnaissance Strip Camera

1. Television Systems

Reconnaissance TV systems are basically the same as commercial closed-circuit TV systems. However, in some cases, they are low-light-level television (LLLTV) systems which are used in night operations. The TV sensor uses optics to focus reflected image-forming light onto either a photoconductor or a photoemissive cathode. As an electron beam scans the "image" (in the form of electrical charges), it produces electrical signals which are recorded permanently on video tape or displayed in real time on a cathode ray tube (CRT), or both. The resolution is based on the size of the image sensor, the number of lines scanned, and the spot size of the electron scanning beam. See Section VI for additional information on resolution. Video information (in electrical

form) lends itself to air-to-ground transmission to a remote station where image interpreters can immediately evaluate the imagery. Figure 14 shows an example of LLLTV imagery.



NOT REPRODUCIBLE

Figure 14. Television Imagery from a Low-Light-Level Television System

2. IR Raster Scanners

Although IR raster scanners operate differently than TV systems, they produce the same type of output. The IR video signals are used either to drive a CRT for immediate viewing or to produce a permanent record on photographic film. Like the TV systems, the IR raster scanner is usually mounted in a forward-looking position so that targets may be viewed and action taken before the enemy becomes aware of the approaching aircraft. The acronym for a forward looking infrared sensor is FLIR (pronounced fleer).

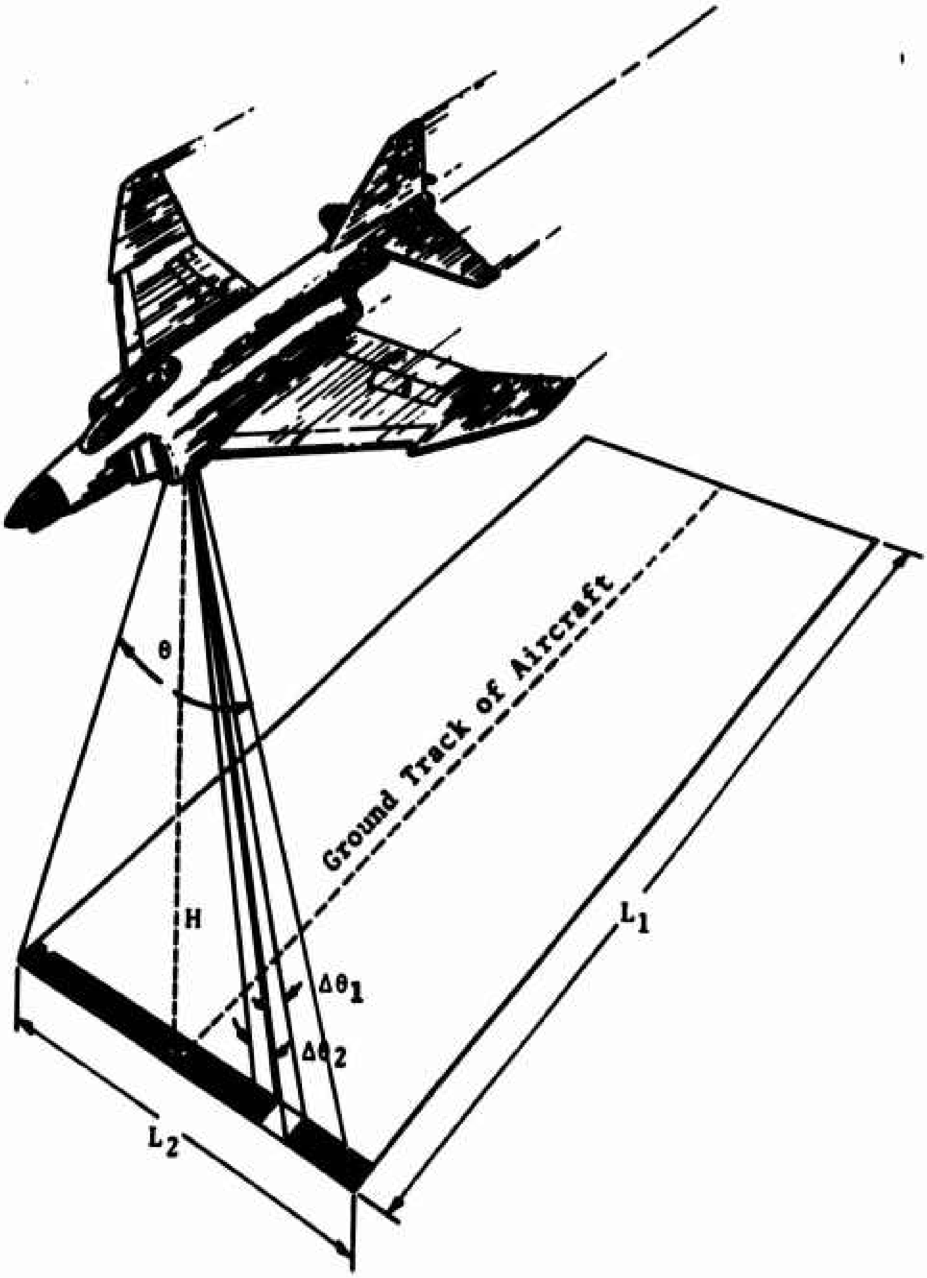
IR raster scanners are designated by the letters AN, a slash, three letters, and one or two numbers. An example is AN/AAD-4, where the AN originally stood for Army-Navy, but now represents the Joint Electronics Type Designation System (JETDS). The first letter after the slash represents the class of installation; in this example, the A denotes piloted aircraft. The second letter after the slash indicates the type of equipment; in this example, A signifies invisible light. The third letter after the slash designates the purpose of the equipment; in this example, the D stands for direction finder or reconnaissance and/or surveillance. Finally, the number 4 represents a particular model of this type of equipment. The AN/AAD-4 is a forward-looking infrared (FLIR) raster scanner.

Line Scanners

Line scanners operate differently than raster scanners since they scan in only one dimension. Usually mounted in the downward-looking position, they scan across the line of flight (or perpendicular to the aircraft's direction). The aircraft's movement provides the second dimension to the imagery. Figure 15 illustrates how line scanners generate an area. The imagery produced by line scanners is a long strip and is formed similarly as the imagery produced by strip cameras. The sensor information is used to record a permanent record on photographic film or to drive a CRT for immediate viewing, or both. Line scanners have the advantages of operating during day or night and of utilizing a different portion of the spectrum, other than the visible, in which to detect and identify targets. However, they are not as versatile as the raster scanners since they do not image an area during a relatively short period of time but must depend upon aircraft movement to provide the second dimension of the area coverage. Therefore, the line scanner has the same disadvantage as the strip camera since it should be stabilized to ensure proper spatial relationships on the imagery. When the line scanner is downward-looking, it has the inherent capability of providing near map-like imagery (depending upon the geometry of the image recorder), but the target cannot be detected until the aircraft has flown over the target area. Line scanners are either active or passive; IR line scanners are passive, and laser line scanners are active.

1. IR Line Scanners

These line scanners operate primarily in either the 3- to 5-μm or the 8- to 14-μm band of the IR spectrum. Since contrasts between targets and backgrounds vary from band to band, both bands have preferred applications. These systems can be used during the day or night and are generally effective in weather ranging from clear to light haze and limited cloud cover. Figure 16 shows IR imagery in the 8- to 14-μm region.



H = Absolute Altitude
L_1 = Ground Distance Covered by Aircraft Movement
L_2 = Ground Distance Covered by Scanner Movement
θ = Angular Coverage of Scanner
$\Delta\theta_1$ & $\Delta\theta_2$ = Instantaneous Field-of-View of Sensor in Lateral and Longitudinal Directions

Figure 15. Area of Coverage Produced by a Line Scanner

Figure 16. Infrared Imagery from a Downward-Looking Infrared Line Scanner

IR line scanners are identified as IR raster scanners except for the third letter and sometimes the first letter. For the IR line scanners, the third letter is S, instead of D, which denotes detecting and/or range and bearing, or search; and the first letter is sometimes U, instead of A, which stands for general utility. Typical IR line scanners are the AN/AAS-18, the AN/AAS-21, and the older AN/UAS-4.

2. Laser line scanners

Laser line scanners operate in the visible, near IR, and intermediate IR portion of the spectrum and differ from IR scanners primarily because they are active rather than passive systems. The laser line scanners consist of a transmitter (laser) with heat exchanger, power supply, receiver, and recorder. In the present systems, the weight and size of these components require aircraft that are larger than the conventional modified-fighter aircraft. Figure 17 shows the imagery produced by a typical laser line scanner. Since laser line scanners sweep the terrain beneath the aircraft, the receiver must be synchronized to follow the laser in order to receive the laser energy reflected from the target area. As in most raster and line scanners, current sets can produce only 8 to 12 shades of gray compared to about 21 for aerial cameras.

Microwave Sensors

Microwave sensors operate within various bands of the microwave region of the EM spectrum. There are two basic types of microwave sensors: passive and active. The passive microwave sensors operate in the shorter wavelength regions, between 1 and 3 mm. The passive sensors collect energy composed of reflected, emitted, and transmitted radiation. The microwave bands generally used by radar are I, J, and K bands; the most commonly used band is the I band. The first radars developed were brute force, or non-coherent, types and depended upon very narrow beamwidths and shorter wavelengths for achieving satisfactory resolution. Newer developments in radar have produced coherent systems which yield high-resolution imagery. Although the actual antenna length may be only 5 to 10 feet, the system integrates signals reflected from the terrain over the length of the synthetic aperture which is usually several thousand feet long. Currently these coherent systems are used only with side-looking radar (SLR), and their returned signal is recorded in the form of phase histories on photographic film. After this film has been developed, an optical correlator with a coherent light source, such as a laser, is used to expose a second film on which the radar map imagery is produced. Radars in aircraft are usually either forward-looking or sideward-looking.

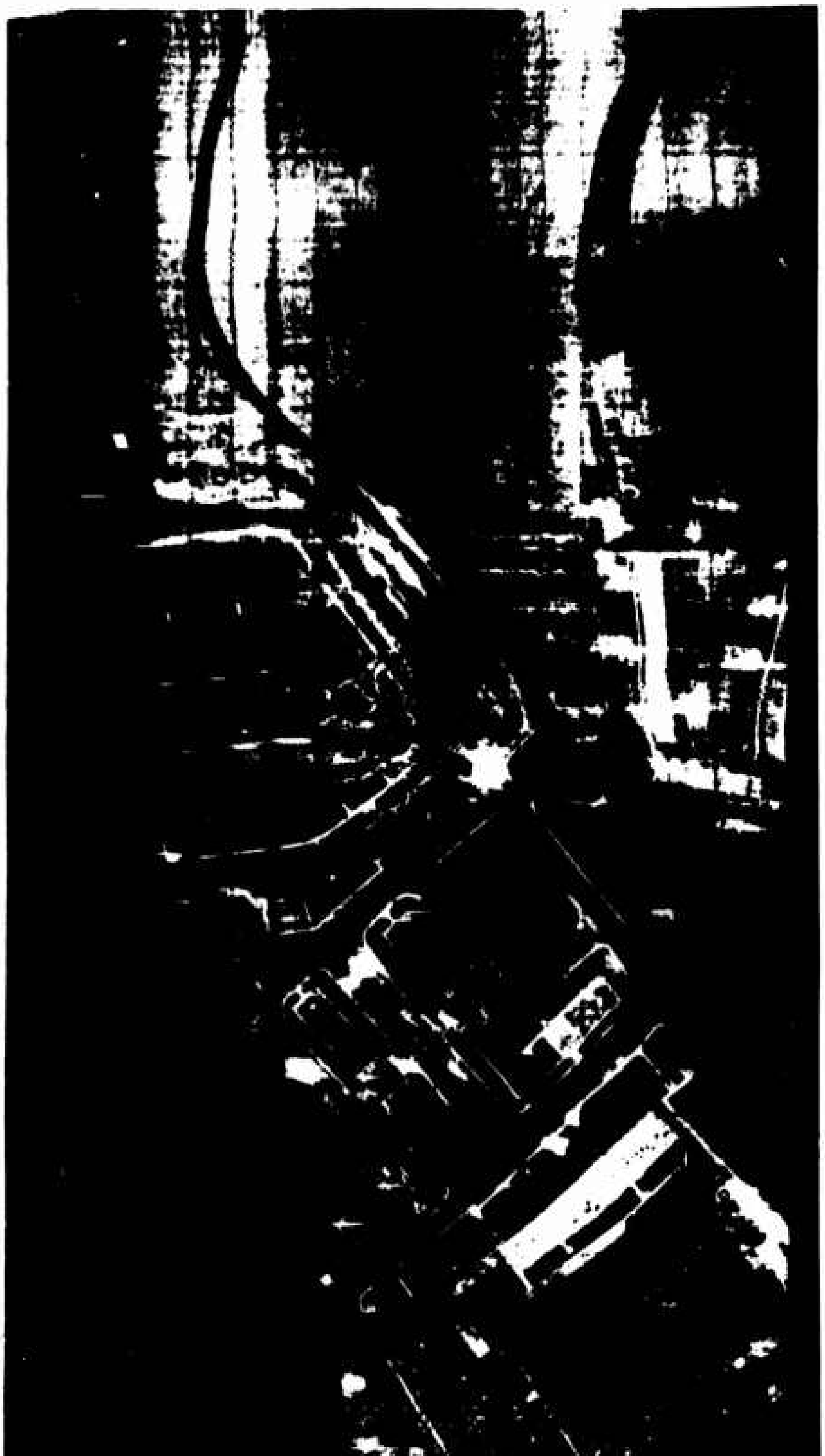


Figure 17. Imagery Produced by a Laser Line Scanner in the Visible Region of the EM Spectrum

1. Forward-Looking Radars

Forward-looking radars generally are used for weather, terrain avoidance, and bombing. A plan position indicator (PPI) type of display is installed in the aircraft to display the radar imagery to the navigator or the weapons delivery officer.

2. Side-Looking Radars

Side-looking radars (SLR), or as sometimes called side-looking airborne radars (SLAR), scan the terrain to the side of the aircraft. Used primarily in surveillance of borders, front lines, and lines of communication, these sensors produce map-like imagery. Ranges from the aircraft to the imaged area vary from about 1 to 100 nautical miles. In addition to being a mapping radar, they sometimes have a moving target indicator (MTI) feature. The MTI images can be superimposed on suppressed radar imagery to assist the observer in locating a moving target in relationship to its background. Since MTI indicates only that an object is moving, it does not suffice for target identification. For example, under the right aspect angle, an observer viewing SLR MTI imagery of large waves crashing on a beach may interpret them as landing vessels.

Radars employ the same type of designations as raster and line scanners. Typical sets are the AN/APQ-102, AN/APD-7, and AN/APS-94. After the slash in each of these designations, the first letter represents the type of vehicle in which the sensor is installed; the second, the type of sensor installed; and the third, the purpose of the sensor. In summary, again after the slash, the first letter A stands for piloted aircraft; the second letter P represents radar; and the third letters Q, D, and S denote direction finder; reconnaissance and/or surveillance; and detecting and/or range and bearing, or search, respectively. Figure 18 is imagery produced by a coherent side-looking radar.

Direct-Viewing Devices

Direct-viewing devices are used in reconnaissance missions to detect enemy movements. Although these devices have been designed primarily for small aircraft, models are being developed for high-performance aircraft. Some examples of direct-viewing devices are as follows:

1. Binoculars

Binoculars are the most widely used direct-viewing devices. In addition to their use in detecting enemy targets, some binoculars, incorporating precision reticles in the object lens,

can be used as range (slant) finders to determine the distance to the target. When these reticles are aligned with a target of known height, the angular displacement of the target and hence the distance to it may be computed. New models are being developed which use convergence or binocular stereo techniques.

Figure 18. Imagery Produced by a Side-Looking Radar

2. Image Intensifiers

Although classified with direct-viewing devices, image intensifiers produce imagery indirectly. When light photons strike a photoemissive cathode, the cathode gives off five or six electrons for every photon. The electrons are then focused onto a visible phosphor screen. Image intensifiers are used with TV systems to produce LLLTV. Hand-held devices can also be used with binoculars to enable the observer to see targets at night. A prime disadvantage of these systems is the lower resolution capability which can be correlated with increased sensitivity.

3. Helmet-Mounted Sights/Displays

Helmet-mounted sights and displays are currently being developed for crew members of high-performance aircraft. The helmet-mounted sight has already been used in helicopters to aim weapons systems at a target viewed by the pilot. Still under development are helmet-mounted displays which will enable a pilot or other crew member to look at a particular portion of the terrain by using an associated sensor. As the sensor is directed toward the target by the helmet movement, it generates TV imagery on the display. Figure 19 shows one of these helmet-mounted displays currently under development.

Figure 19. A Developmental Helmet-Mounted Display

Displays

Except for direct-viewing devices, sensor information is displayed on either a photographic film or a CRT. Photographic film has been used far more extensively because of the large amount of data that can be recorded on a single frame of film. For example, a 4-1/2- by 4-1/2-inch image with a 50-lp/mm resolution and 21 levels of gray can store approximately 2.74×10^9 bits of data, whereas a conventional TV display with 10 shades of gray presents only about 3.68×10^6 bits of data. However, since the film must be developed before it can be viewed, no film-recording sensor can provide the immediate imagery of a real-time reconnaissance system.

Rear-Projection Displays

A rear-projection viewer is used in aircraft to display the sensor imagery on photographic film. These viewers project an image from the developed film onto a diffused glass plate. The operator may vary the film speed or stop at a particular frame for short periods to inspect suspected areas for targets or to decide whether an additional pass should be made over a target to properly identify it. The imagery of these systems lags behind that of real-time systems by as much as 3 to 10 minutes. Figure 20 shows a typical rear-projection film-viewing device.

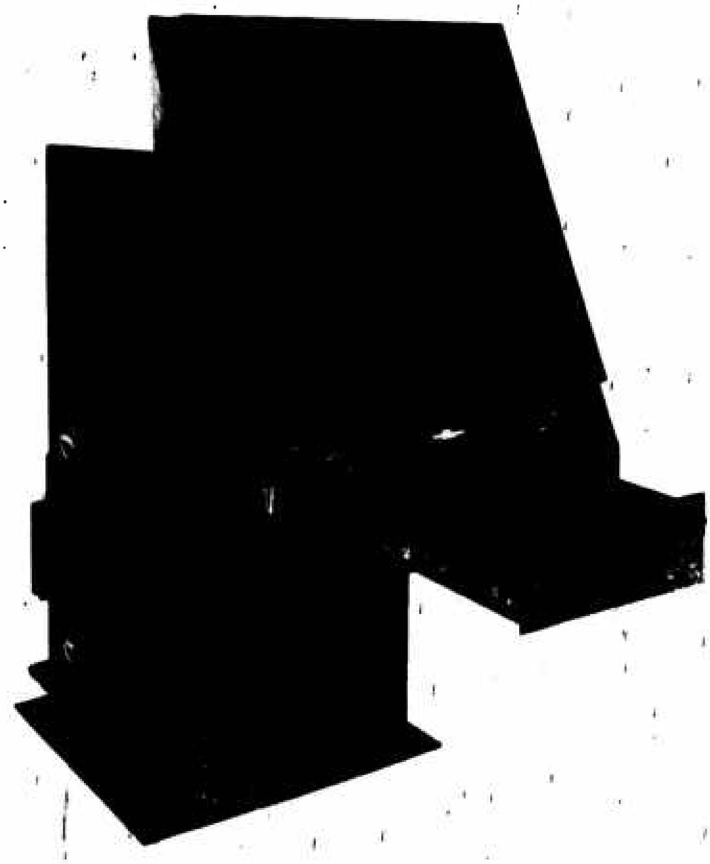


Figure 20. A Rear-Projection Film Viewing Device

Cathode Ray Tubes

The imagery of sensors which produce data in the form of electrical signals is normally presented on CRT displays. Although the resolution of such displays is not as good as that of photographic film, the CRT displays provide real-time information. Television and IR raster scanners use this type of display. Figure 21 shows a typical CRT display.

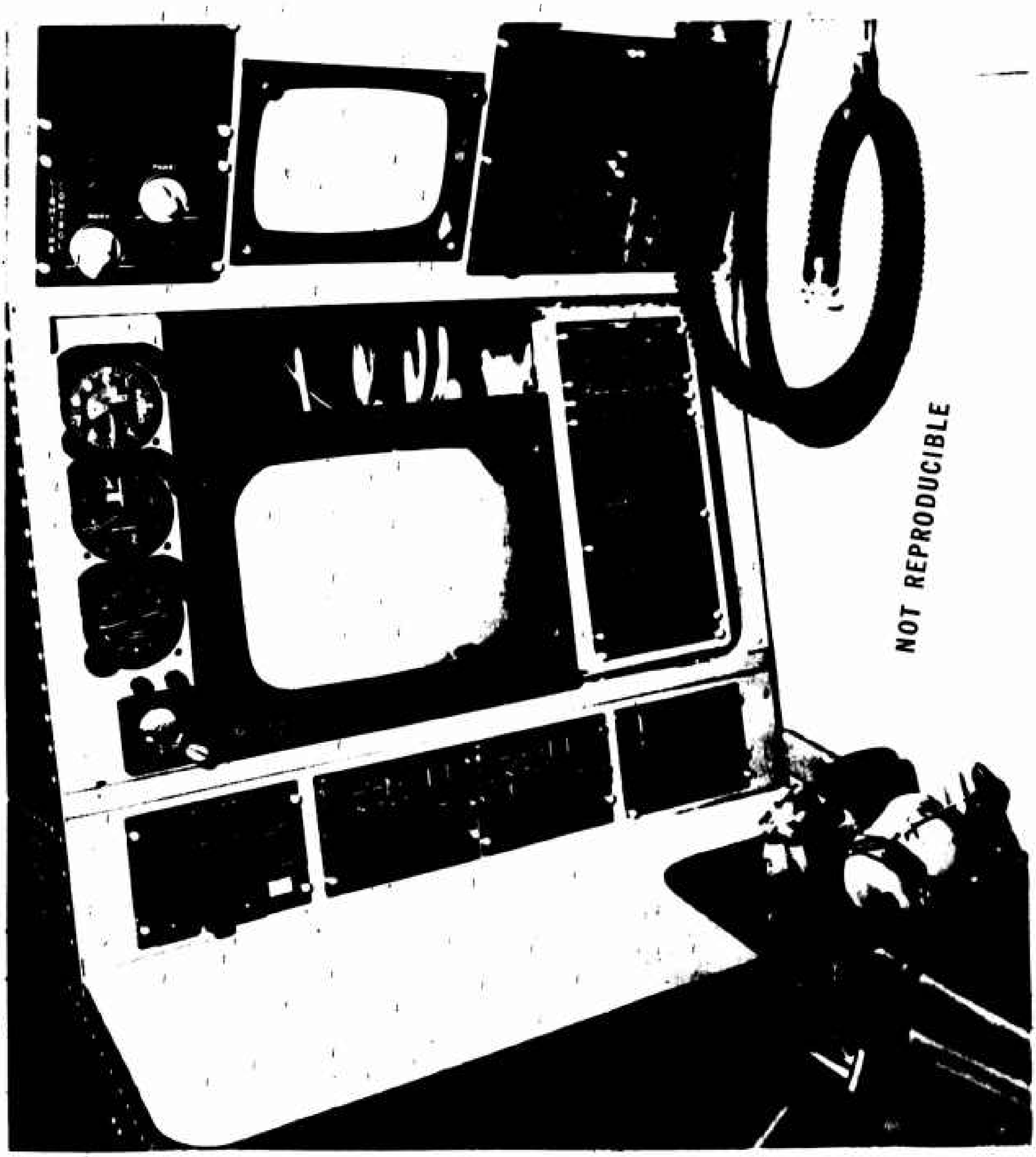


Figure 21. A Cathode Ray Tube Display

SECTION V

RECONNAISSANCE/SURVEILLANCE MISSIONS

The terms "aerial reconnaissance" and "aerial surveillance" are often used interchangeably. Within the Air Force the term "aerial reconnaissance" denotes all aerial remote-sensing missions which gather information about hostile or potentially hostile areas where fluid or semifluid ground-warfare conditions prevail; of prime concern are transient and fleeting targets. "Aerial surveillance" denotes aerial remote-sensing missions which systematically cover large areas for the updating of existing information about the hostile or potentially hostile forces or threats. Generally, fixed targets are of prime concern. Reconnaissance/surveillance missions may be classified by type, or coverage, and by prime mission purpose.

CLASSIFICATION BY TYPE

The three basic types of reconnaissance missions are visual, imagery, and electronic warfare support measures (ESM). These missions are discussed below.

Visual Type

In this type of reconnaissance, the aircrew observe the target scene either directly or by using a cockpit viewing device. Target detection and identification are nearly simultaneous, and voice or data transmission can follow immediately. Usually these missions are flown by low-performance aircraft.

Imagery Type

This type of reconnaissance employs all of the electro-optical and radar types of sensors. The outputs from these devices are either recorded on photographic film or presented on video displays for interpretation. In some sensor systems both hardcopy imagery and displays are generated simultaneously. Both high- and low-performance aircraft may be used, depending on the purpose of the mission and the hostility of the environment.

Electronic Warfare Support Measures (ESM) Type

ESM reconnaissance missions seek enemy electronic transmitters and take the necessary action against them to permit the accomplishment of air and ground force objectives. If the information

from such missions is recorded and analyzed on the ground for planning future operation, the missions are defined as electronic intelligence (ELINT) missions.

CLASSIFICATION BY COVERAGE

There are three types of reconnaissance coverage: area search or area coverage, route search or strip coverage, and specific search or pinpoint coverage.

Area Search or Area Coverage

The aerial camera is usually employed for such missions. Designed to encompass large areas, this type of coverage is used for the initial intelligence data base, for updating the initial data base, for combat mapping, and for planning future operations.

Route Search or Strip Coverage

This type of coverage is used to survey lines of communication (LOC's), such as roads, railroads, and waterways, and border areas, where penetration is not feasible or desirable. Either high- or low-performance aircraft are used for this coverage, depending upon the threat environment. Since most targets are fast-moving, in-flight reports must generally be sent to the commander for immediate action.

Specific Search or Pinpoint Coverage

With prime interest in such targets as surface-to-air missile (SAM) sites, this type of coverage is used to confirm or deny enemy activity, to locate specific high-threat targets, to conduct targeting for pre-strike planning, and to perform post-strike analysis or bomb damage assessment (BDA).

CLASSIFICATION BY PRIME MISSION PURPOSE

The reconnaissance/surveillance mission is intended generally to gather information about an enemy or potential enemy so that the commander may optimize the use of available forces and weapons. There are, however, specific uses of reconnaissance/surveillance information. These missions can be broken down into those where the reconnaissance and resulting action or strike are accomplished within minutes, and those where the activity is delayed because of planning and analysis on the ground. The former use real-time and near real-time displays, and the latter use ground-processed imagery.

Real-Time and Near Real-Time Missions

These reconnaissance missions provide the timely information needed for missions engaged in the destruction of targets. Some of these missions, such as most interdiction missions, may be wholly initiated by and carried out within the Air Force, and others, such as close-support missions, may be initiated by the Army and coordinated with the Air Force. Examples of such missions are as follows:

Reconnaissance-Strike (Recce-Strike) Mission

The recce-strike mission is usually flown by low- or medium-performance aircraft. Interdiction or the close-support type of mission uses one or two aircraft to locate and attack targets. When two aircraft are used, one locates the targets and the other makes the strike. Forward Air Control (FAC) and Strike Control and Reconnaissance (SCAR) aircraft are used to locate the targets. Strike and SCAR aircraft attack the targets. The gunship type of aircraft has the capability of performing both acquisition and strike functions.

Artillery Adjustment Mission

This mission is a coordinated Army-Air Force mission in which the FAC or SCAR aircraft locate targets and direct the adjustment of the artillery fired by Army batteries. The artillery adjustment mission uses low-performance aircraft in a permissive environment. This mission type may also lend similar support to Naval forces in shore bombardments.

Operation Planning Missions

The operation planning missions are designed soley for meeting the operation planning requirements of the Air Force and Army. Examples of such missions are as follows.

Pre-Strike Planning Mission

Both the Army and Air Force require pre-strike planning missions. The Army is interested primarily in the disposition and the targeting of enemy weapon systems 15 to 25 kilometers from their lines or the forward edge of the battle area (FEBA). Determining the potential fire power of the enemy weapon systems has the highest priority in these missions. The Air Force usually requires targeting for counter air, suppression of enemy aircraft and airfields, and destruction or neutralization of surface-to-air missile (SAM) sites and conventional anti-aircraft artillery (AAA) positions. The Air Force is also interested in the interdiction of lines of communication (LOC's). Choke points (bottlenecks) in each route are selected as prime targets. Marshalling

yards and bridges are examples of choke points for railroads. Regardless of the user, these missions usually seek specific targets or a group of targets within a relatively small area.

Post-Strike Analysis Mission

The post-strike analysis, commonly called bomb damage assessment (BDA), is a reconnaissance mission flown after the target has been attacked. The resulting analysis may require either another strike or surveillance to monitor target restoration efforts. Thus the pre-strike planning and post-strike analysis missions for a particular target may be cycled.

Combat Mapping Mission

The combat mapping mission is flown over areas where existing maps lack the detail needed for accurate air and ground-force targeting. High-precision aerial cameras may be employed in both low- and high-performance aircraft. The latter aircraft type, however, must be used in a high-threat environment.

SECTION VI

PLANNING FOR RECONNAISSANCE/SURVEILLANCE MISSIONS

In planning an aerial reconnaissance/surveillance or recce/strike mission (such as the gunship program), those available sensors whose characteristics are most suited for the detection and identification of the anticipated targets must be carefully selected for a successful mission.

SCALE

The scale of the recorded sensor information is the ratio of the image plane to the target plane, and has been partially discussed in Section 3. Three factors affect the scale of the imagery: (1) the effective focal length of the sensor system, (2) the altitude of the aircraft, and (3) the attitude of the sensor to the ground.

Focal Length

The equivalent focal length (EFL), sometimes called the effective focal length, is the distance from the rear nodal point in an optical system to the image plane. Figure 22 shows the EFL in relationship to the ground plane, image plane, and altitude. For non-optical sensor systems, the relationship is difficult to show; nevertheless, all image-forming systems have an EFL.

Altitude (Absolute and Barometric)

Absolute altitude is the distance from the sensor to the terrain directly below the aircraft. The barometric altitude is the distance between the sensor and the mean sea level. If only the barometric altitude is known, then the terrain height (elevation) must be known to determine the absolute altitude. Figure 23 shows the relationship between the absolute and barometric altitudes.

Attitude

The attitude of the sensor in relationship to the ground plane is another important factor in determining the scale of the imagery. If the sensor is in a vertical position (downward-looking), then the scale will generally be the same throughout the image format. There are, however, two exceptions: First, in panoramic cameras and certain line scanners, the scale across the line of flight changes from a larger scale at the center to progressively smaller scales toward the edge of the format. Second, the scale of the

imagery changes as the heights of objects above sea level in the ground plane vary (over fairly flat terrain these changes are usually insignificant). When the sensor is purposely tilted with respect to the ground plane, the image is oblique (either side or forward looking). If the apparent horizon can be seen on the imagery, it is a high oblique; if not, it is a low oblique. In either case the scale of the imagery decreases from the foreground to the background (with such scaling, the term "background" is used for distances farther from the sensor than the foreground). Figure 24 shows the relationship of vertical, high oblique, and low oblique sensor attitudes. The nadir is the point on the earth's surface directly below the sensor, and the horizon line is the line from the sensor toward the horizon.

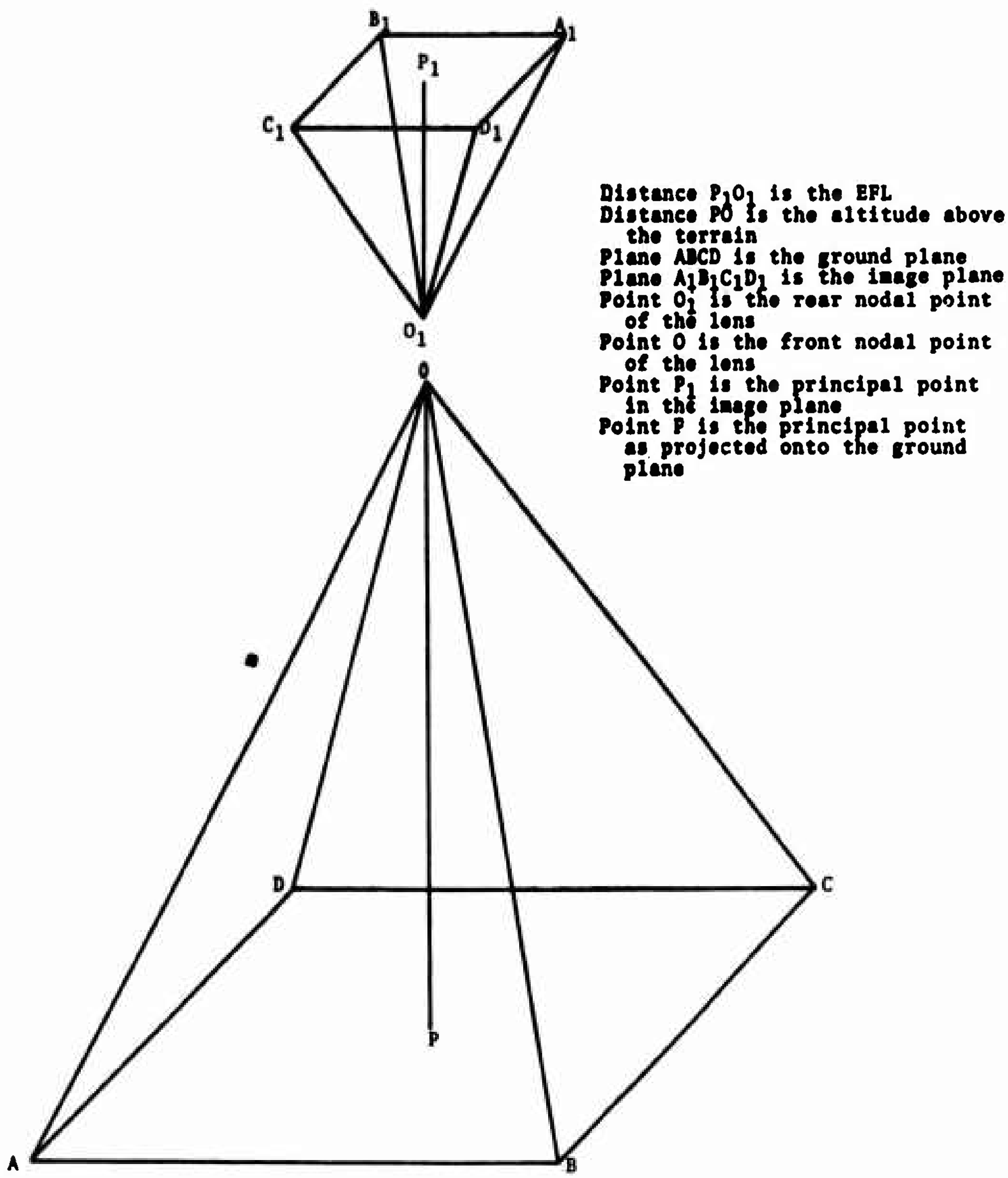


Figure 22. Relationship of EFL, Altitude, Image Plane, and Object Plane

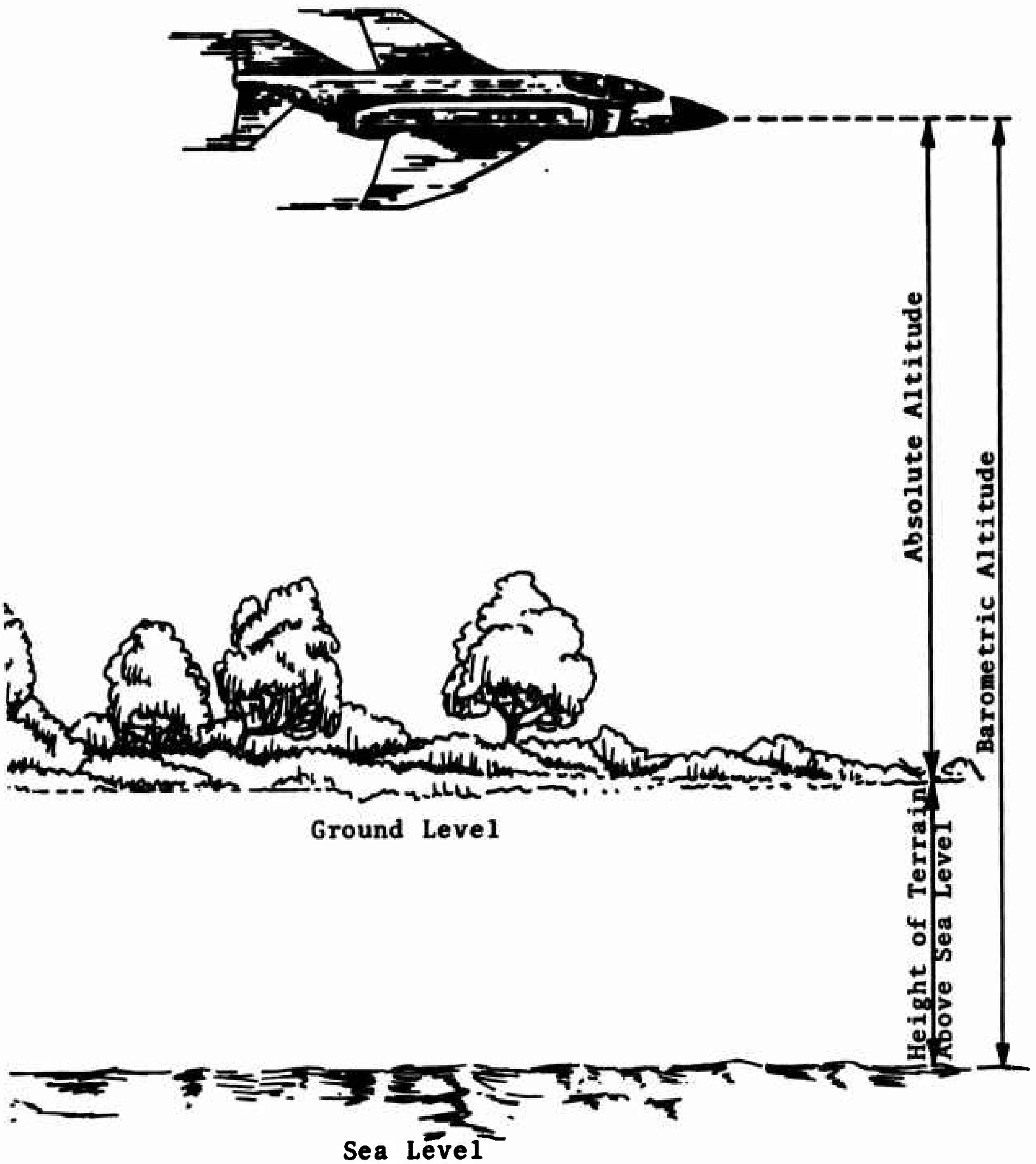
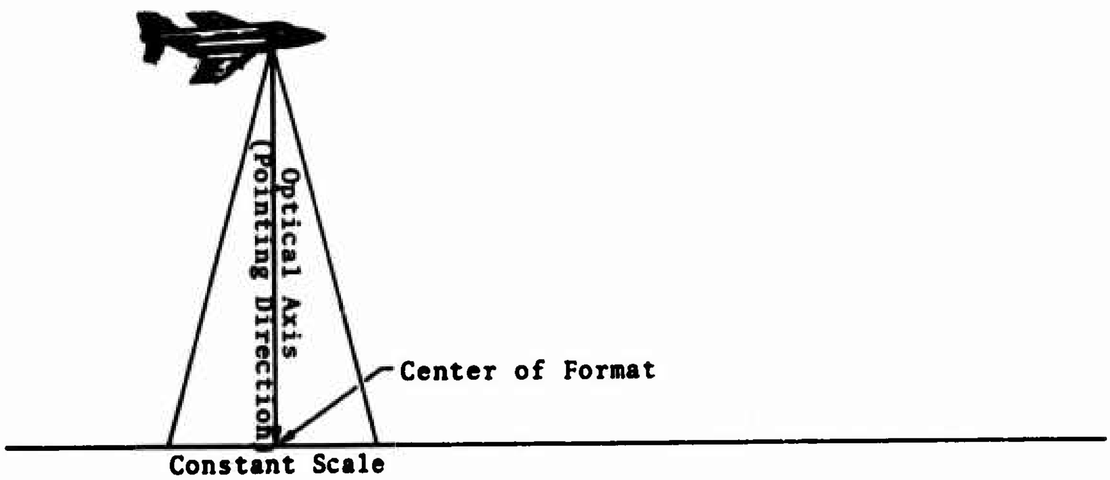
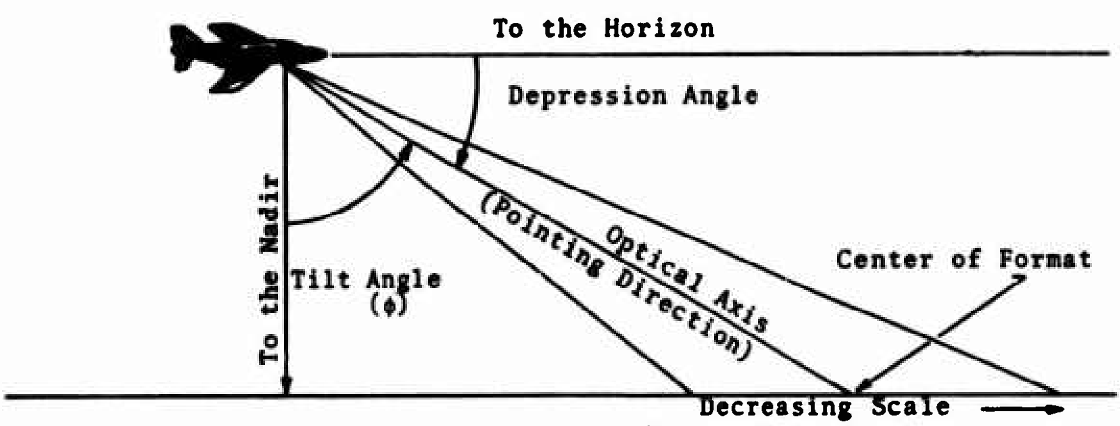


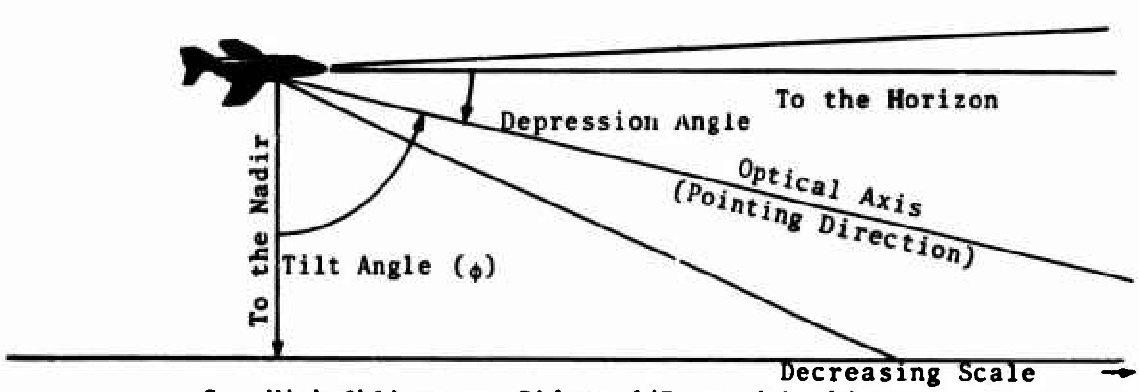
Figure 23. Relationship Between Barometric and Absolute Altitudes



A. Vertical or Downward Looking



B. Low Oblique or Sideward/Forward-Looking



C. High Oblique or Sideward/Forward-Looking

Figure 24. Relationship of Vertical, High and Low Oblique to Ground Coverage

The scale of the imagery at the center of the format may be computed when the EFL, the altitude, and the tilt angle are known. The scale factor (the reciprocal of the scale) is computed by dividing the altitude by the EFL and then multiplying the product by the secant of the tilt angle as follows:

$$\text{scale factor} = (H \sec \phi)/F$$

where

H = absolute altitude
F = equivalent focal length (in the same units as H)
ϕ = tilt angle

GROUND COVERAGE

Ground coverage refers to the area imaged by a sensor. For cameras and raster scanners, the imagery is generally on one frame, but for line scanners and side-looking radar (SLR), the imagery is in a strip format. In lateral (crosstrack) coverage, line scanners and SLR's normally give only the angular field of view and the ranges, respectively. Four interrelated factors determine the imaged ground coverage format: (1) field of view (FOV), (2) altitude, (3) attitude, and (4) focal length (FL).

Framing Sensors

A framing sensor forms an image with well-defined X and Y dimensions. Examples of framing sensors are cameras and raster scanners. The angular field of view (FOV) of these sensors is usually along the flight line and across the flight line. In most sensors the FOV is the same for each direction. Sometimes the diagonal FOV is given. To determine the ground area imaged by a framing sensor, the FOV, altitude, and attitude must be known. If the EFL and format are known, but the FOV is not, the FOV may be computed by the following equation:

$$\theta = 2(\tan^{-1} \frac{d}{2F})$$

where

θ = field of view
d = image format size
F = focal length in the same dimensions as those of the format

Figure 25 illustrates the parametric relationships.

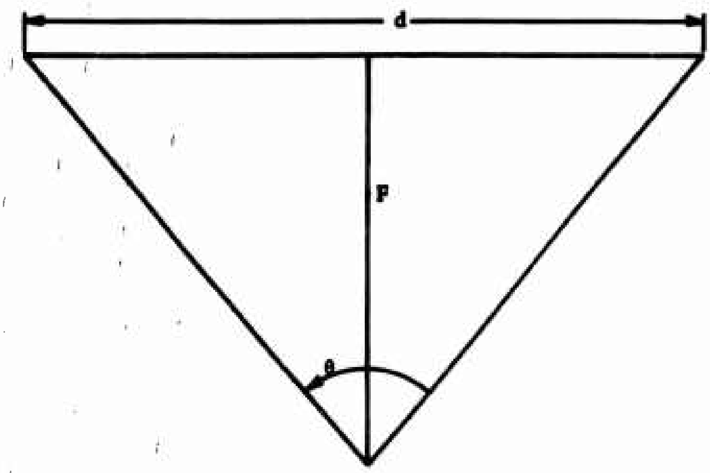


Figure 25. Relationship Between Focal Length (F), Image Format Size (d), and Field of View (θ)

To determine square ground coverage for vertical or downward-pointing sensors, the following equations may be used:

$$L_1 \text{ or } L_2 = 2(H \tan \frac{\theta}{2})$$

where

L_1 = ground distance along the flight line
L_2 = ground distance across the flight line
θ = field of view either along or across the direction of flight
H = absolute altitude
NOTE: H and L_1/L_2 must be in the same units.

then

$$A = L_1 \times L_2$$

where

A = ground coverage in squared dimensions

Line Scanners

Line scanners scan across the flight path. As the aircraft moves along the flight path, it provides the other dimension to the imagery. The ground coverage is thus a function of both the angular FOV for the crosstrack dimension and the distance flown by the aircraft during a specific time period. In this case the distance traveled can be determined by the simple equation

$$L_1 = VT$$

where

L_1 = ground distance along the flight line
V = speed of the aircraft
T = time

Therefore, except for D_1, the ground coverage computation for the line scanners is the same as that for the framing sensors.

Side-Looking Radar

Side-Looking Radar (SLR), sometimes called side-looking airborne radar (SLAR), displays its imagery similarly as line scanners; however, instead of giving the angular field of view for crosstrack coverage, SLR gives range in either kilometers or nautical miles. If the radar imagery is used for targeting, the ground or slant range must be known since the type of range makes a difference in the actual target's position, particularly at the closer ranges. If the distance across the imagery is expressed as slant range and the distance to the far edge is given as slant range, then the distance across the ground may be found by the following equations (see Figure 26):

$$S_d = S_f - S_n$$

where

S_d = displayed ground distance
S_f = slant range to the far edge of the format
S_n = slant range to the near edge of the format

and

$$\phi_f = \cos^{-1}(H/S_f)$$

$$\phi_n = \cos^{-1}(H/S_n)$$

where

ϕ_f = tilt angle to the far edge of the imagery
ϕ_n = tilt angle to the near edge of the imagery
H = absolute altitude of the aircraft

then

$$L_2 = H(\tan \phi_f - \tan \phi_n)$$

Since the L_1 expression is the same as that for line scanners, the area ground coverage (A) for SLR is the product of L_1 and L_2.

MOUNTING

The mounting of the sensor determines what area the sensor will "see" in relationship to the aircraft. There are three primary types of mounts: fixed, stabilized, and steerable.

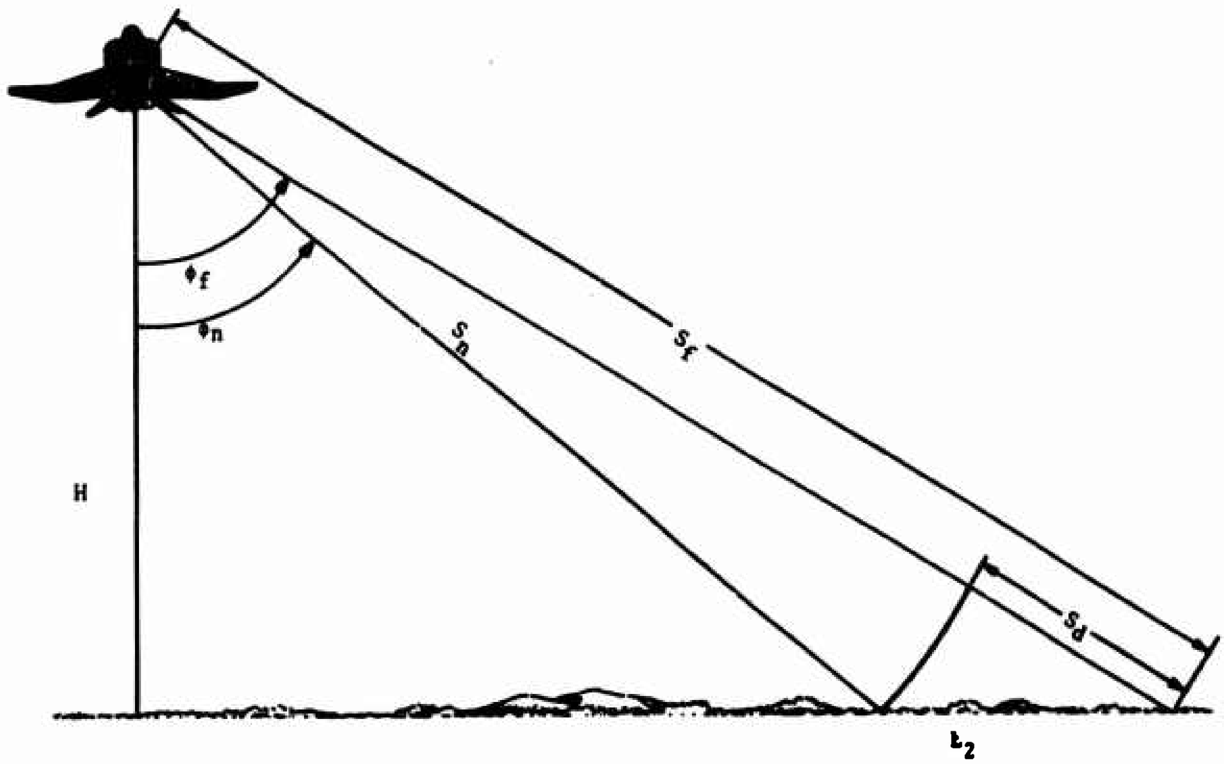


Figure 26. Difference Between Displayed Slant Range (S_d) and Ground Range (L_2) Coverage of SLR's

Fixed Mounts

Fixed mounts are the most commonly used. As the name implies, the sensor is mounted rigidly to the aircraft (although some rigid mounts have isolation vibrators to reduce aircraft vibration to the sensor, they are still considered fixed). When the aircraft rolls, pitches, or yaws, the sensor likewise rolls, pitches or yaws. There are three primary attitudes in which sensors are normally fixed-mounted: downward-looking, forward-looking, and sideward-looking.

Downward-Looking (Vertical)

Except for some line scanners and the panoramic camera, the scale of the imagery in the downward-looking or vertically mounted sensor is approximately the same throughout the format, which permits relatively easy targeting. Another advantage is that vegetation and terrain produce the least amount of masking with the sensor in this position. A major disadvantage is that since an aircraft has passed the target by the time it is imaged by a real-time or near real-time display, mobile targets could disperse and seek cover before a recce-strike aircraft could make a second pass to mark the target for the strike aircraft.

Forward-Looking (Forward Oblique)

The prime advantage of a forward-looking sensor is the capability of imaging a target before actually flying over it. Such imaging permits both recce-strike aircraft and gunships to perform their respective missions in a single pass. In this position, however, vegetation and terrain are likely to mask the target, and the scale of the target and background changes throughout the format.

Side Looking (Side Oblique)

Mounting the sensor in a side-looking mount allows the aircraft to fly a route parallel to the target area. Normally this mode is used where the target cannot be overflown because of either low survivability of the aircraft over the target or political reasons. In this type of surveillance, radar with a moving target indicator (MTI) is usually the prime sensor; however, sometimes special long-focal-length cameras are used. An advantage is that the aircraft can fly beyond the range of hostile ground fire. Disadvantages are the change in scale and the masking of targets by vegetation and terrain. In addition, the aircraft would usually require two passes to either mark the target or deliver ordnance upon it.

Stabilized Mounts

Because of the constant orientation afforded by its gyros and torquing motors, a stabilized mount keeps the sensor pointed in the same direction as long as the aircraft movements do not exceed the limitations of the mount. Stabilized mounts are usually used in the vertical (downward-looking position) for precision targeting or mapping.

Steerable/Tracking Mounts

Steerable mounts are gyro-stabilized devices whose direction may be remotely controlled by an operator. For example, an operator may change a sensor from a vertical position to a given depression angle, either forward or sideward, or both. Akin to the steerable mount is a gyro-stabilized tracking mount. In addition to steering, the mount can automatically track a target. The operator may use the mount in the steerable mode, and once a target has been located, he may put the mount in a tracking mode whereby the mount will follow the target as the aircraft flies by it. The prime advantage of the tracking mode is that the target can be studied for longer periods over different aspect angles. This mode is used primarily in real-time displays where hard imagery is not available.

RESOLUTION

Resolution denotes the smallest object that can be seen (or resolved). Several components in a sensor system affect the resolution; for example, in an aerial camera, the lens, film, and movement reduce the resolution from its theoretical level. The diffraction limit is found by the equation

$$\Delta\theta_d = \frac{1.22\ \lambda}{D}$$

where

$\Delta\theta_d$ = angular resolution in radians
λ = wavelength of the light source
D = diameter of the aperture in the same units as λ

Other factors being equal, the resolution decreases with longer wavelengths and increases with wider aperture lenses or larger antennas. Another factor which affects the resolution is the contrast between the target and background. Energy reflected or emitted by the target is scattered to some extent by the atmosphere and the atmosphere back-scatters non-imaging energy into the sensor. Such scatter reduces the contrast between the target and background. In general, the shorter the wavelength or the higher the altitude, the less contrast between target and background.

Optical Systems

Optical systems are measured in line pairs per millimeter (lp/mm). Figure 27 illustrates a bar target consisting of black-and-white spaces used for testing the resolution of optical sensors. Each black-and-white space represents one pair of lines. The smallest black-and-white image which can be resolved is usually considered the limiting resolution. The number of these pairs that can be imaged in 1 mm is then the resolution of the system.

TV and Other Raster Scan Systems

TV and other raster scan systems use a resolution criterion similar to that for optical systems. In raster scan systems an electron beam is swept across some photo-sensitive surface. The number of times (or the number of lines) that the beam must sweep the format to cover the entire surface is given in lines. Standard television uses 525 sweeps, or lines, in covering the format. If the format dimensions are known, then the TV resolution can be determined by dividing the total number of sweeps by the dimension of the side of the format which is perpendicular to the sweeps. For example, if the format is 0.375 by 0.500 inches and the raster scan is along the 0.5-inch dimension, then the 9.52 mm (or 0.375 inches) divided into 525 gives a resolution of

55.1 TV lines per mm. To equate TV lines to optical line pairs, the following equation is useful:

$$R_o = 2\sqrt{2}\, R_t$$

where

R_o = optical resolution in line pairs
R_T = TV resolution lines
$\sqrt{2}$ = Kell factor

NOTE: The Kell factor of $\sqrt{2}$ is the normally accepted value; however, some disagreement exists among authorities.

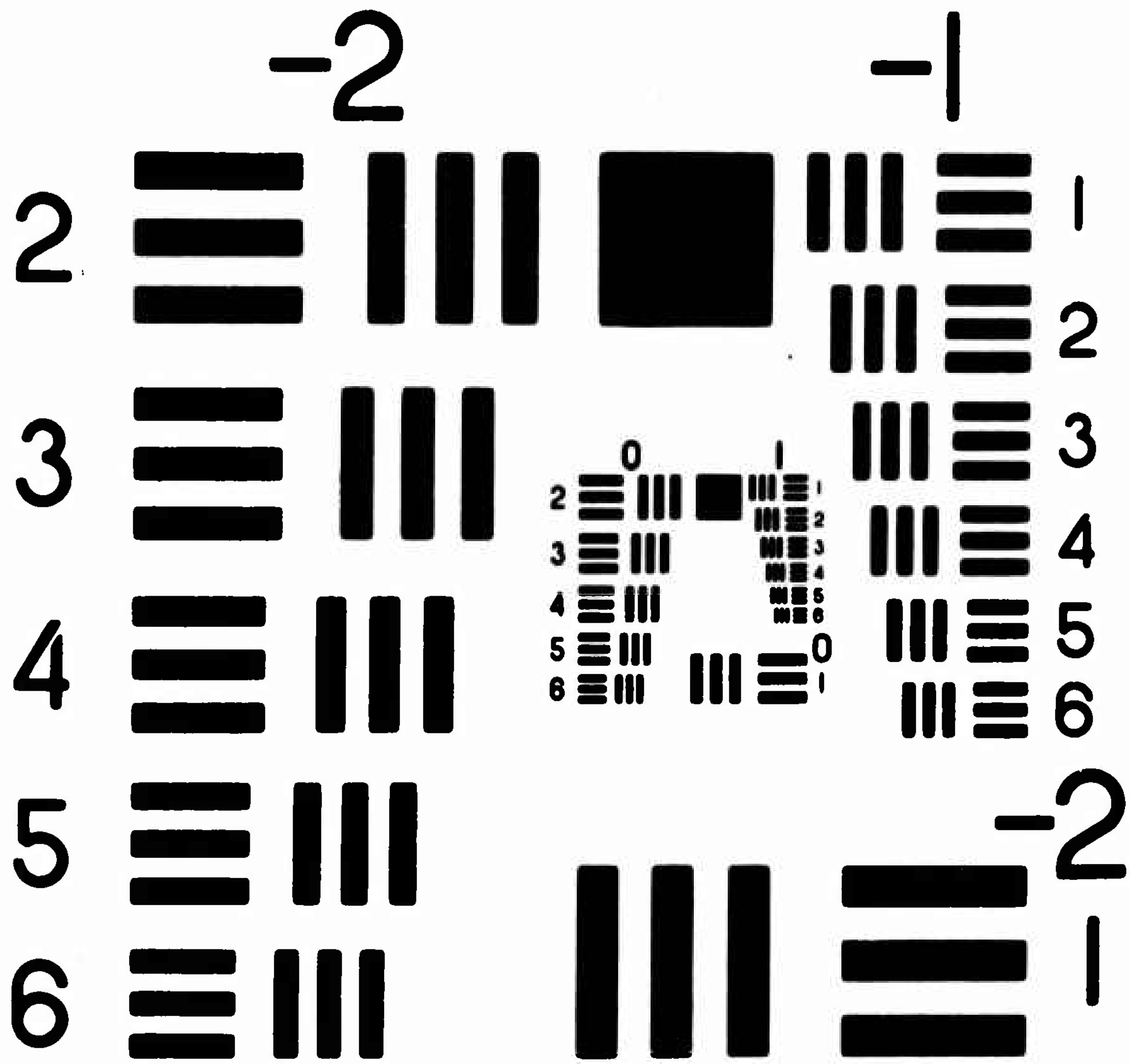
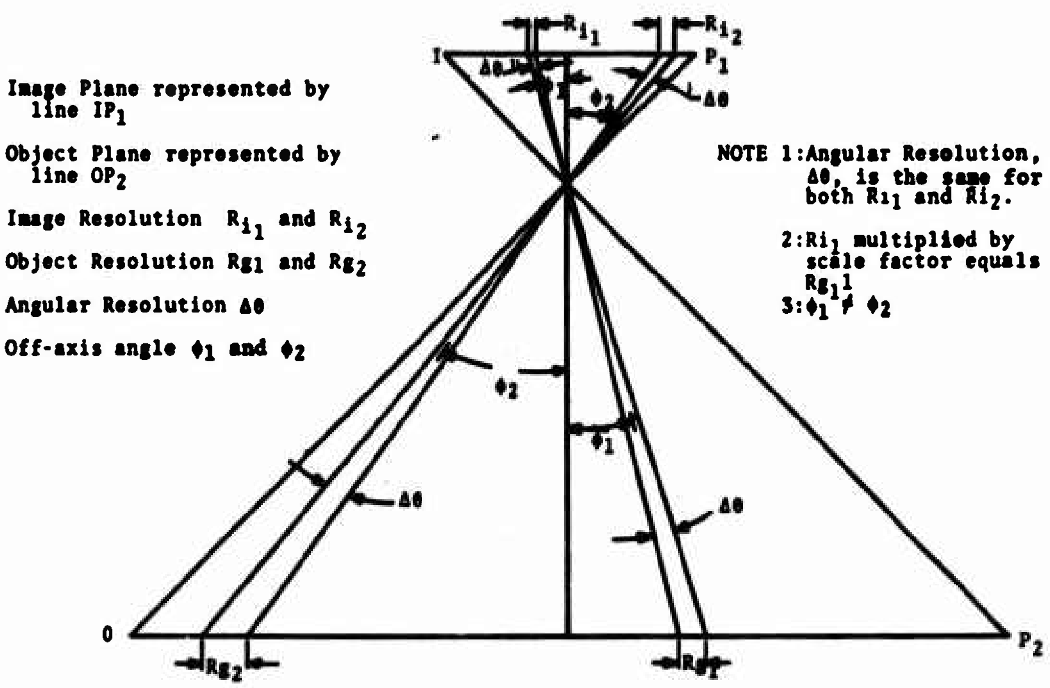


Figure 27. Standard USAF-1951 Resolution Target

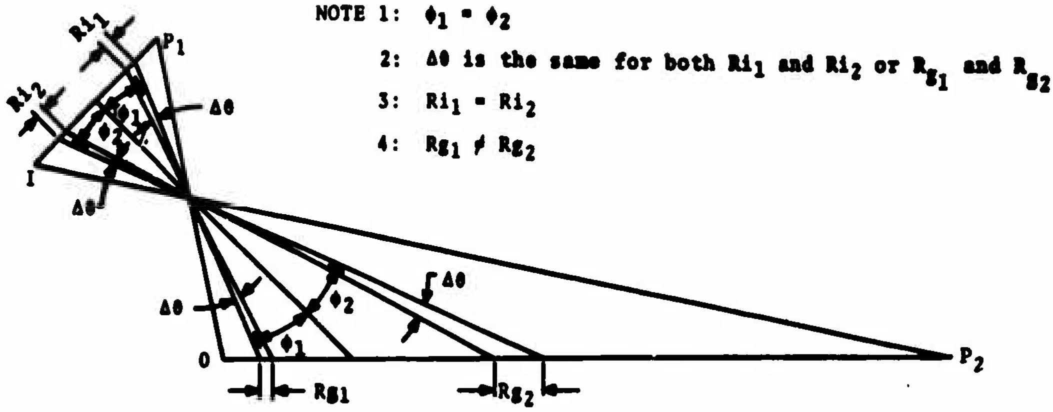
Image-Ground Resolution

In the above paragraph, image resolution was discussed in determining the size of the smallest image that can be seen in the format. Ground resolution is the corresponding resolution used in determing the size of the smallest object that can be seen on the ground. There is not always a direct correlation between image and ground resolution. In Figure 28A, both the image and object plane are parallel, and the resolution varies according to the off-axis angles θ_1 and θ_2 of the target; whereas in Figure 28B, the planes are not parallel, and the resolution varies as a function of distance or slant range to target, as well as of the off-axis angles (θ_1 and θ_2). Some sensor recorders do not record the image in a plane, but in an arc around the rear nodal point of the lens system. In these systems the image resolution remains constant (or nearly so) throughout the format, but varies as a function of the offset angle for ground resolution. These sensor recorders are used with some line scanners. Figure 29 shows an example of this type of sensor system.



A. Resolution in Object Plane Directly Related to Resolution in Image Plane Where Image and Object Planes are Parallel

Figure 28. Relationship Between Resolution in Image and Object Planes



B. Resolution in Object Plane Not Directly Related to Resolution in Image Plane Where Image and Object Planes are not Parallel

Figure 28. Relationship Between Resolution in Image and Object Planes - Concluded

Image Plane represented by arc IP_1
Object Plane represented by line OP_2
Image Plane Resolution Ri_1 and Ri_2
Object Plane Resolution Rg_1 and Rg_2
Angular Resolution $\Delta\theta$
Off-Axis Angle ϕ_1 and ϕ_2

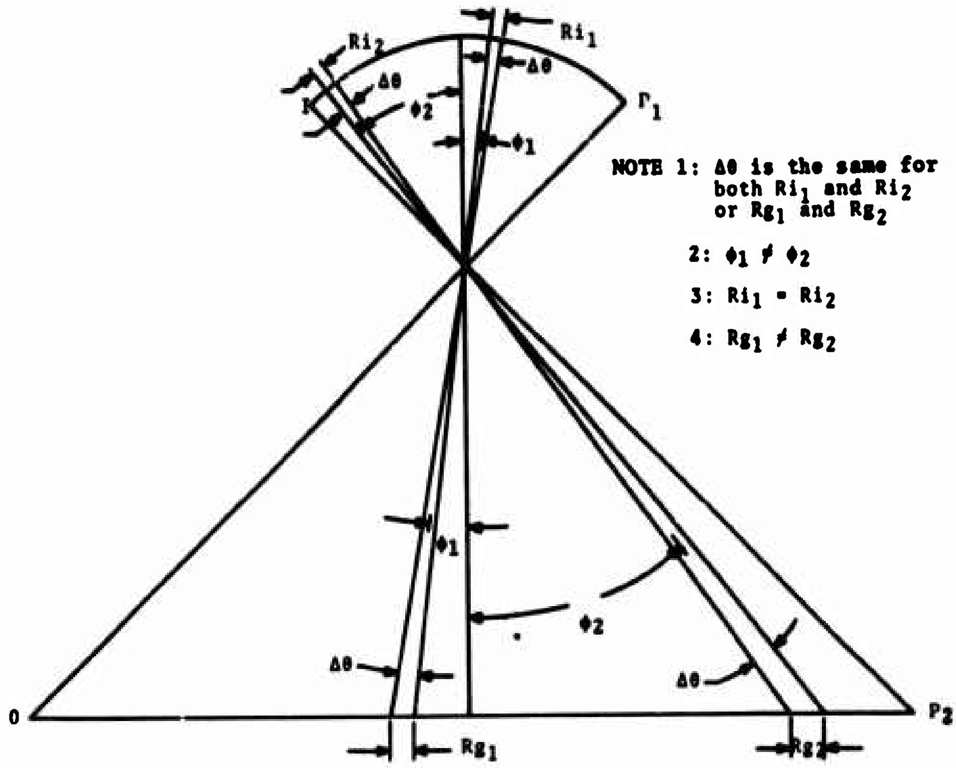


Figure 29. Relationship Between Resolution in Image and Object Plane Where Image Plane is Curved

ENVIRONMENTAL FACTORS

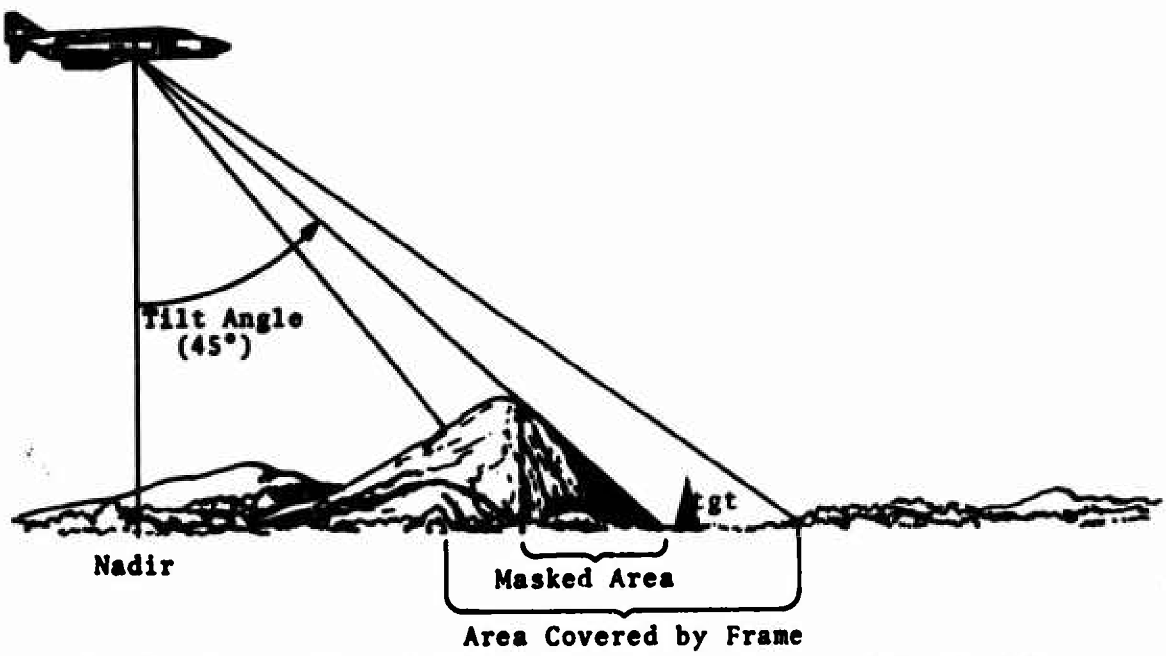
Two environmental factors (ground and atmospheric conditions) influence the sensor response by affecting the reflection and emission characteristics of targets and backgrounds.

Ground Conditions

The relief of the terrain features and the height and density of the foilage are two prime factors in considering the ground conditions.

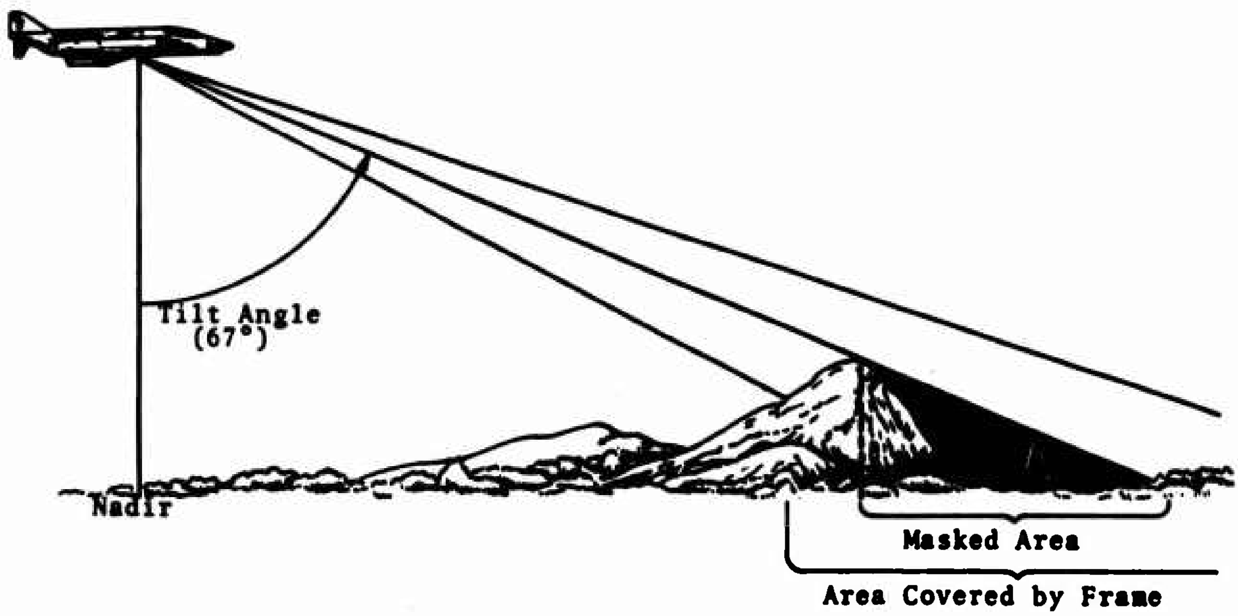
Terrain Relief

When the sensor is not in a vertical position, the terrain relief, that is, hills and other eminences, will mask possible targets. At a given altitude, the greater the tilt angle (or the smaller the depression angle), the more ground will be masked by intervening objects. Figure 30 shows the effect of terrain relief as a function of sensor attitude.



A. Small Area Masked Behind Hill Due to Terrain Relief with a 45° Tilt Angle

Figure 30. Examples of Masking of Areas Due to Terrain Relief as a Function of Tilt Angle



B. Large Area Masked Behind Hill Due to Terrain Relief with a 67° Tilt Angle

Figure 30. Examples of Masking of Areas Due to Terrain Relief as a Function of Tilt Angle - Concluded

Foliage

Ground cover or foliage varies primarily as a function of climatic and seasonal changes. Foliage may vary from virtually none in desert and tundra regions to trees from 200 to 300 feet high in tropical rainforests with several canopies three and four layers deep, as well as underbrush. Such foliage creates problems for remote sensors.

Atmospheric Conditions

The effects of atmospheric conditions on sensors vary with the sensor type. The conditions which have the greatest effect and therefore the greatest importance in selecting a sensor are atmospheric attenuation, diurnal lighting, and weather.

Atmospheric Attenuation

Atmospheric attenuation is the reduction of the radiant energy passing through the atmosphere. It is caused by (1) the scattering of the energy from molecules of gas particles (Raleigh scattering) and from dust and vaporized particles (Mie scattering)

and (2) the absorption of the energy by such gases as water, oxygen, and carbon dioxide. Since the effect of atmospheric scattering decreases as the energy wavelength increases, longer wavelength sensors receive more radiant energy, except where atmospheric absorption is a predominant factor. Figure 31 shows a curve of the radiant energy transmitted through a clear atmosphere.

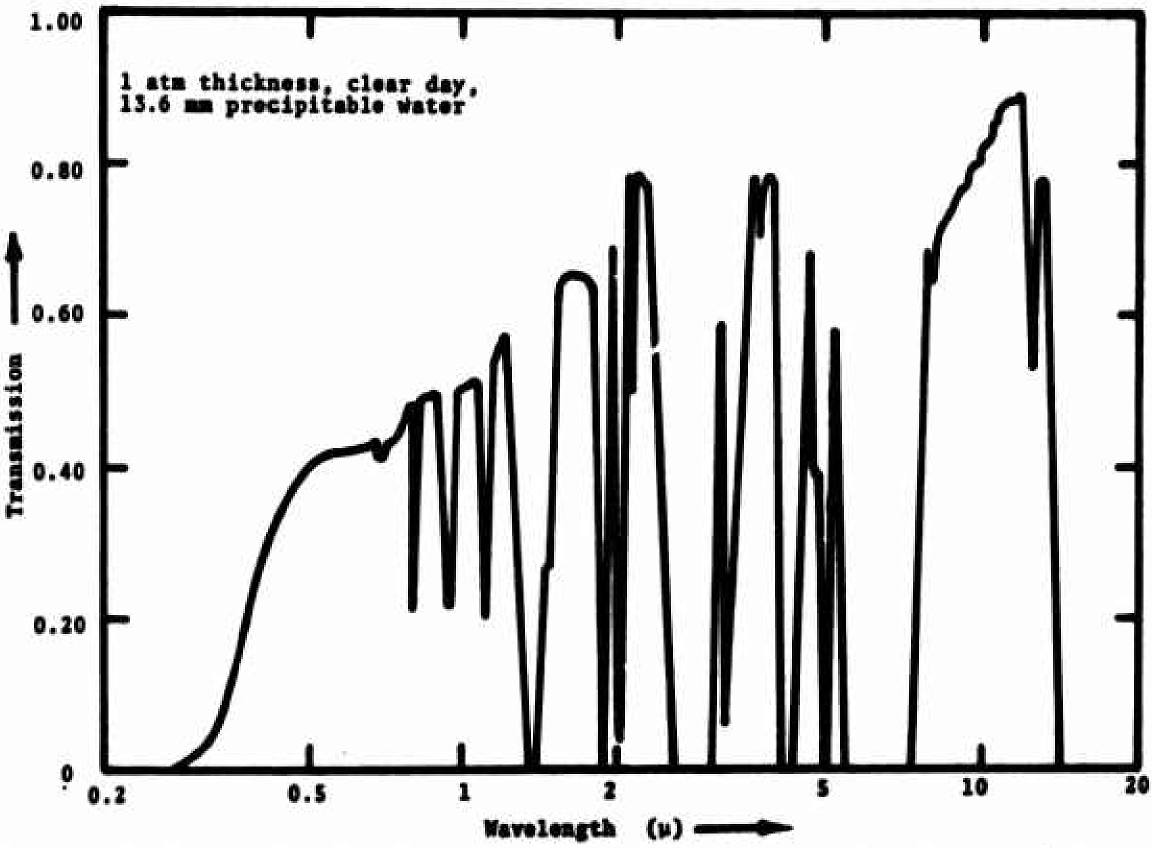


Figure 31. Atmospheric Attenuation of Energy in the Untraviolet, Visible, and Infrared(to 20 μm) Regions of the EM Spectrum

Diurnal Lighting

Diurnal lighting is basically divided into daytime and nighttime lighting. Sensors are designed to operate during daytime or nighttime lighting, or both. Table I lists the diurnal lighting during which current electro-optical and microwave sensors operate.

Weather Conditions

Inclement weather conditions adversely affect all electro-optical sensor systems. The primary advantages that the intermediate and far infrared systems have over the visible-wavelength sensors are that they can operate during day and night conditions with or without natural illumination sources and they can penetrate light haze and light rain.

TABLE I

Diurnal Operation of Electro-optical and Microwave Sensors

	Daytime	Nighttime	Both
Camera			
Frame			A,B
Panoramic	B		
Raster Scanners			
TV	B		
LLLTV		B	
FLIR			B
Line Scanners			
IR			C
Laser			B,D
Microwave			
SLR (SLAR)			E

A. A light source must be used at night and the sensor must be in the vertical (downward-looking) position.

B. Sensor cannot penetrate clouds or overcast.

C. Sensor cannot penetrate heavy clouds or overcast.

D. Effectiveness depends upon the wavelength and power of the laser. Most laser line scanners are used only at night.

E. All-weather (except heavy rain) sensor systems.

TARGET FACTORS

The types of targets found in tactical reconnaissance fall into three distinct groups: fixed, transient, and fleeting.

Fixed Targets

Fixed targets are permanent objects such as bridges, industrial complexes, airfields, power facilities, and buildings. Since these targets are relatively large, the imagery need not have as high a resolution as required for transient and fleeting targets under the same flying altitudes and slant ranges. When missions must be flown at higher altitudes with longer slant (stand-off) ranges because of high-threat conditions, high-resolution sensors are required. Since most fixed targets are deep within enemy-held territory, high-performance aircraft are required for the reconnaissance mission.

Transient Targets

Transient targets are temporarily positioned objects whose pending removal may require immediate targeting. Such targets include bivouac areas, staging areas, truck parks, supply dumps,

and antiaircraft artillery (AAA), surface-to-air missile (SAM), and surface-to-surface missile (SSM) sites. Most of these targets are fairly close to the forward edge of the battle area (FEBA), from less than a mile to perhaps 10 to 15 miles. Exceptions are some AAA, SAM, and SSM sites which are in the enemy's rear echelons.

Fleeting Targets

Fleeting Targets have the highest mobility and include personnel, tracked and wheeled vehicles, trains, and surface vessels. Because of their potential movement and evasion, targeting decisions must be made promptly. Recce-strike and gunship aircraft are currently best suited for the destruction of these targets.

AIRCRAFT SURVIVABILITY FACTORS

Aircraft survivability depends on the potential threat of air and ground-to-air defenses. The degree of such threat depends largely on how effective the air and counter-air operations of friendly forces is in suppressing AAA fire and in neutralizing enemy air power. If SCAR and FAC aircraft can operate over enemy territory with acceptable attrition rates, the area is considered a low-threat environment. If not, it is classed as a high-threat environment, which is usually deep within enemy territory and which requires high-performance aircraft for the reconnaissance mission.

GLOSSARY

Abandoned: Status of an identified target or component thereof determined from imagery to be (1) not in use, (2) unoccupied, and (3) not in a condition to be of immediate use.

Absorber: An object which readily absorbs radiation in a given portion of the electromagnetic spectrum, that is, ultraviolet, visible, infrared, or microwave; a good absorber is also a good emitter, but a poor reflector.

Active (Sensor): Any aerial remote sensor which must use a man made energy source to "illuminate" the target in order to detect the reflected energy from the target.

Active (Target): Status of an identified target or component thereof determined to be currently operating or in use.

Activity Indicator: Any aspect of the imaged scene that points to past, present, or future activity. While not in themselves targets, activity indicators may originate from targets. Examples of activity indicators are waste heat from a tank or such disturbances of background as thermal trails made by animals or machines.

Aerial Exposure Index (AEI): Defined as 1/2E, where E is the exposure (in meter-candle-seconds) at the point on the toe of the characteristic curve where the slope is equal to 0.6 of the measured gamma. The processing conditions should always be specified. AEI is used for black-and-white negative aerial films. This system of determining aerial film exposure will be replaced by the Aerial Film Speed (AFS) method within the next several years.

Aerial Film Speed (AFS): Defined as 3/2E, where E is the exposure (in meter-candle seconds) at the point on the characteristic curve where the density is 0.3 above base plus fog density. The processing conditions such as time, temperature, agitation, and developer are strickly defined in ANSI Standard PH 2.34-1969. AFS is used for black-and-white negative aerial film.

Aerial Observer (AO): An aircrew member whose primary function is to locate enemy activity and positions and to relay information to the appropriate authority.

Aerial Photograph, Oblique: A photograph taken with the camera axis directed between the horizontal and the vertical.

a. High oblique. An oblique photograph in which the apparent horizon is within the field of view.
b. Low oblique. An oblique photograph in which the apparent horizon is not within the field of view.

Aerial Photograph, Vertical: An aerial photograph made with the optical axis of the camera approximately perpendicular to the earth's surface.

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Aerial Photographic Reconnaissance: Information obtained by aerial photography. There are three types:

a. Strategic photographic reconnaissance.
b. Tactical photographic reconnaissance.
c. Survey/cartographic photography (air photography taken for survey/cartographic purposes and for survey/cartographic standards of accuracy).

Aerial Reconnaissance: The acquisition of intelligence information by employing aerial vehicles in visual observation or by using sensory devices.

Aerial Surveillance: The systematic observation of air, surface, or subsurface areas by visual, electronic, photographic, or other means for intelligence purposes.

Aeronautical Chart: A chart which represents a given area of the surface of the earth and is used primarily in air navigation. Aeronautical charts usually represent topographical features readily identifiable from aircraft, and contain aeronautical data helpful in navigation.

Airborne Laser Illuminator Ranging and Tracking System: An airborne laser system that is used to illuminate and track a target so that a strike aircraft can delivery ordnance (stores) on the target.

Airborne Operator: An aircrew member who is trained in the operation of an aerial reconnaissance remote sensor and the interpretation of the sensor's output.

Air Intelligence: Military intelligence directly concerning air activities of the enemy, weather, order of battle, antiaircraft defenses, airfields, and target information.

Air Speed: The speed of an aircraft relative to the surrounding atmosphere.

Altimeter: An instrument which indicates the vertical distance above a specified datum plane; usually an aneroid barometer which utilizes relative pressure of the atmosphere.

Altimeter, Radar: An instrument for indicating absolute altitude from the datum plane by a pulse technique. This is accomplished by measuring the lapsed time between the transmission of microwaves from an aircraft and the reception of the reflected waves, based on pulse technique.

Altitude: Height of a point or object in space above a datum plane.

Altitude, Absolute: Height above the surface of the earth as differentiated from altitude (height above sea level). It is sometimes referred to as radar altitude.

Altitude, Radar: Synonymous with absolute altitude.

Altitude, True: Height above mean sea level.

Angle of Incidence (radar): The angle which the transmitted radar beam makes with a perpendicular to a target surface at the point of incidence of contact.

Angle of Reflection (optics): As measured from the normal, the angle at which a reflected ray of light leaves a surface.

Angle of Reflection (radar): The angle which the radar beam on leaving the reflecting surface makes with the perpendicular to the surface.

Antenna (radar): That device which directs and transmits the energy from the radar transmitter and receives the energy reflected from the target.

Antiaircraft Artillery (AAA): Conventional tube artillery which is used against aircraft.

Aperture: The opening in a lens diaphragm through which light passes.

Aperture, Relative: The ratio of the equivalent focal length to the diameter of the entrance pupil of a photographic lens. Expressed as f:4.5, etc. Also called f-number, stop, aperture stop, diaphragm stop, or speed.

Apparent Horizon: The visible line of demarcation between land/sea and sky.

Area Search: Reconnaissance of limited or defined areas.

Area Target: A target consisting of an area rather than a single point.

Armed Reconnaissance: An air mission flown with the primary purpose of locating and attacking targets of opportunity, that is, enemy material, personnel, and facilities, in assigned general areas or along assigned ground communication routes, and not for the purpose of attacking specific briefed targets.

Associated Apparent Features: The various apparent or recognizable returns which support or are interrelated with a target.

Attenuation: The reduction in the intensity of radiation on passage through matter where the effect is usually due to absorption and scattering. Reduction of radiation intensity caused by the atmosphere is called atmospheric attenuation.

Attitude: Orientation of an aerospace vehicle as determined by

the inclination of its axes to some frame of reference, usually the earth.

Automatic Exposure Control (AEC): A device on an aerial camera system which automatically controls the amount of energy received by the film. This is accomplished by changing the aperture and/or the shutter speed.

Automatic Gain Control (AGC): A device on a remote sensor recorder or display for keeping the average illumination level constant.

Azimuth: The direction of a line given as an angle measured clockwise from a reference direction, usually north.

Back Focal Distance: See Focal Length.

Background: Any distribution or pattern of radiant flux from the surfaces of natural terrain, vegetation, and cultural features that may interfere with detecting, locating, or identifying targets.

Backscattering (atmospheric): That portion of electromagnetic energy which is reflected backwards from the atmosphere (Raleigh backscattering) and particles suspended in the atmosphere (Mie backscattering) to the illumination source and a remote sensor. This is non-imaging energy which reduces the contrast between imaged objects; its contrast-reduction effect is most significant at the shorter wavelengths and over the medium to long slant ranges.

Backscattering (radar): The scattering of energy of the radar reflected signal.

Bandwidth: The range of frequency required to transmit information at a specific rate. Television, for example, requires a much greater bandwidth than does sound. Also used to describe the transmission characteristics of the transmitting and receiving apparatus.

Bar Scale: A graduated line on a map, plan, photograph, or mosaic by means of which distances may be measured in terms of actual ground distances. Also called graphic scale.

Basic Cover: Aerial imagery of a given area of interest obtained for general intelligence requirements and with which later cover can be compared to discover any changes that may have occurred.

Beam Width (radar): The angle between half-power intensities in a lobe pattern.

Bearing: The situation or direction of one point with respect to another or the compass.

Binary Coded Decimal Value (BCD): The system of data annotation used with the code data matrix block on the image recording film.

Blackbody: A hypothetical object which absorbs all, and reflects none, of the radiation incident on its surface. A blackbody is also the perfect emitter. As the name implies, a blackbody can usually be approximated by black, sooty surfaces.

Blip (radar): The display of a received pulse on a cathode ray tube.

Bloom: Loss of detail in highlights due to energy saturation in sensor systems, particulary in TV and in IR raster and line scanners.

Bomb Damage Assessment (BDA): The evaluation of processed imagery of strikes against targets by qualified image interpreters or airborne sensor operators from post-strike missions.

Calls: The operator's identification responses in the viewing situation, for example, the identification of an image object as a truck would be a call of a truck.

Camera, Aerial: A camera specially designed for use in aircraft.

Camera Body: A component of a camera housing mechanical drives and controls and linking the lens cone with the film magazine.

Camera Calibration: The determination of the focal length, the lens distortion in the focal plane, and the location of the principal point with respect to the fiducial marks. The settings of the fiducial marks and the positioning of the lens are ordinarily considered as adjustments, although they are sometimes performed during the calibration process. In a multiple-lens camera, the calibration also includes the determination of the angles between the optical axes of the components.

Camera, Continuous Strip: A camera in which the film moves continuously past a slit in the focal plane, producing a photograph in one unbroken length by virtue of the continuous forward motion of the aircraft.

Camera, Fan: An assembly of three or more cameras, systematically disposed at fixed angles relative to each other so as to provide wide lateral coverage with overlapping images.

Camera Magazine: The removable part of a camera in which the unexposed and exposed portions of film are contained.

Camera, Mapping or Surveying: A camera specially designed for production of photographs to be used in surveying. The prefixes "mapping" and "surveying" indicate that a camera is equipped with means for maintaining and indicating the interior orientation of the photographs with sufficient accuracy for surveying purposes. A mapping camera may be either an aerial mapping camera or a terrestrial mapping camera. The latter is generally used with a universal theodolite; the combination of the two is called a photo theodolite.

Camera Mount: A device used to mount a camera. Some types of camera mounts are automatically stabilized to eliminate vibration and to permit rotation about all axes for leveling.

Camera, Multiple Assembly: An assembly of two or more cameras mounted so as to maintain a fixed angle between their respective optical axes.

Camera, Panoramic: A camera which takes a partial or complete panorama of the terrain. Some designs utilize a lens or prism which revolves about an axis; in other designs the camera itself is revolved mechanically to obtain a panoramic field of view.

Camera Port: The optical quality window in aircraft through which photographs are taken. The quality of aerial photography is no better than the quality and condition of the port.

Camera Recycle Rate: The time required for a camera to operate between successive exposures. When operating at maximum speed, it is called maximum recycle rate or runaway.

Camera Station: The point in space, in the air, or on the ground occupied by the camera lens at the moment of exposure. Also called the exposure station. In aerial photogrammetry the camera station is called the air station.

Camouflage: The disguising of a target with paint, screens, reflectors, or other devices.

Camouflage Detection Photography: Photography utilizing a special type of film (usually color infrared) designed for the detection of camouflage.

Cathode Ray Tube (CRT): A special form of vacuum tube used in various electronic appliances, for example, the picture tube of a television receiver.

Cell, Photoelectric: A device by which light is transformed into electrical energy. It can be used to activate a camera shutter or to measure the intensity of light.

Cloud Cover: The percentage of sky obscured by clouds.

Code Data Matrix: A small information block on the imagery containing columns of dots arranged in coded positions to provide flight data regarding the film.

Coherent Radiation: Coherent radiation, for example, a laser beam, consists of successive wave trains propagated in unison; that is, successive waves are equal in wavelength, frequency, and phase. This consistency of order enables very efficient concentration of energy.

Combat Intelligence: That knowledge of the enemy, weather, and geographical features required by a commander in the planning and conduct of tactical operations.

Combat Surveillance: A continuous, all-weather, day and night systematic watch over the battle area to provide timely information for tactical ground combat operations.

Command and Control System: The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned.

Comparative Cover: Cover of the same area or object taken at different times to show any changes in detail.

Comparator: An optical instrument, usually precise, for measuring rectangular or polar coordinates of points on any plane surface, such as a photographic plate.

Concealment Analysis: Analysis of images from the vertical or oblique viewpoint that will reveal enemy material and military activity under camouflage or natural cover.

Constellation Effect: A group of separated, persistent returns identified by the over-all pattern formed.

Contact Print: A print made from a negative or a diapositive in direct contact with sensitized material.

Contact Report: A report of the enemy made by a field unit, a ship, or an aircraft which is in visual, radio, sonar, or radar contact with him. The first report, giving the information immediately available when the contact is first made, is known as an initial contact report. Subsequent reports containing additional information are referred to as amplifying reports.

Contour Interval: The difference in elevation between adjacent contours.

Contour Line: An imaginary line connecting the points on a land surface that have the same elevation; the line on a map or chart representing points of equal elevation.

Contrast: The actual difference in density between the highlights and the shadows on a negative or positive. Contrast is not concerned with the magnitude of density, but only with the difference in densities. Also, the rating of a photographic material corresponding to the relative density difference which it exhibits.

Convergence of Evidence: The bringing together of several types of information in order that a conclusion may be drawn in the light of all available data.

Coordinates: Linear or angular quantities which designate the position of a point in a given reference or grid system.

Coordinates, Geographic: A system of spherical coordinates for describing the positions of points on the earth. The declinations and polar bearings in this system are the latitudes and longitudes, respectively.

Coordinates, Grid: A plane-rectangular coordinate system based on and mathematically adjusted to a map projection in order that geographic positions (latitudes and longitudes) may be readily transformed into plane coordinates and that the computations relating to them may be made by the ordinary methods of plane surveying.

Coordinates, Photograph: A system of coordinates, either rectangular or polar, describing the position of a point on a photograph. If a two-dimensional system is used, the origin is usually the principal point, but it may be the nadir point, isocenter, one of the fiducial marks, or, in high oblique photographs, the intersection of the horizon and the principal line. The coordinate axes are usually either the fiducial axes or the principal line and a photograph parallel. If a three-dimensional system is used, the origin is either the principal point or the perspective center.

Coordinates, Plane-Rectangular: A system of coordinates in a horizontal plane, used to describe the positions of points with respect to an arbitrary origin by means of two distances perpendicular to each other. The two reference lines passing through the origin at right angles to each other are called the coordinate axes. The distances parallel with the true, or arbitrarily assigned, north-south axis are called the ordinates, the y-coordinates, or the total latitudes. The distances parallel with the true, or arbitrarily assigned, east-west axis are called the abscissas, the x-coordinates, or the total departures. A plane-rectangular coordinate system is used in mapping areas of such limited extent that the errors introduced by substituting a plane for the curved surface of the earth will be within the required accuracy. In mapping, the north and east directions are positive and the south and west directions are negative. In practice, to avoid the use of negative coordinates, the origin of the system is usually chosen to be a point to the southwest of the area being mapped; or its coordinates, instead of being zero, are assigned large positive numbers. The great merit of a rectangular-coordinate system is that computations involving positions of points thereon may be performed by the use of plane trigonometry. Plane-rectangular coordinates may or may not be adjusted to a map projection. Also called Plane Coordinates.

Coordinates, Space: A three-dimensional system of rectangular coordinates in which the x- and y-coordinates lie in a reference plane tangent to the earth at a selected point and the

z-coordinate is perpendicular to that plane. This system is used in the extension of horizontal and vertical control through a series of overlapping vertical photographs from an initial point which is the point of tangency of the reference plane. When these coordinates are corrected to allow for the curvature of the earth, they cease theoretically to be true space coordinates because the x- and y-coordinates become distances along great circles at right angles to each other and the z-coordinates are distances perpendicular to the vertical control datum. The use of the term "space coordinates", therefore, should be strictly limited to a three-dimensional rectangular coordinate system which has not been adjusted to the vertical and horizontal control data.

Correlator (Radar): A device that uses the original data film recording of Doppler phase histories to make the radar map film on an optical data processor.

Counterinsurgency (COIN): The operations directed toward the destruction, control, or neutralization of hostile insurgent (guerrilla) forces.

Coverage:
a. The ground area represented on aerial imagery, photomaps, mosaics, maps, etc.
b. The extent to which intelligence information is available in respect to any specified area of interest.

Coverage Index: One of a series of overlays showing all reconnaissance missions covering the map sheet to which the overlays refer.

Crab (aerial photography): The condition caused by failure to orient the camera with respect to the track of the airplane, indicated in vertical photography by the sides of the photographs not being parallel to the principal-point base line. (See Drift.)

Crossover (infrared): A condition in which the target-background is lost because the combined effect of the temperature and emissivity of the target and that of the background cause virtually the same radiant fluxes.

Cultural Level: The extent to which the terrain is built up with man-made structures.

Data Base: Reference material such as imagery, maps, charts, plots, intelligence documents, and target folders.

Data Block: See Code Data Matrix.

Data Link: A communications link whose terminals are suitable for transmission and reception of data.

Datum: A reference element, such as a line or plane, in relation to which the positions of other elements are determined. Also called the reference plane or datum plane.

Declination, Grid: The difference in direction between true north and grid north, also called gisement.

Declination, Magnetic: The angle between true north and magnetic north. The magnetic declination is different for different places and is continuously subject to change.

Decoy: Any installation or object used to mislead the enemy.

Definition (degree of):
a. The ability of a sensor system to record fine detail.
b. The distinctness or clarity of detail or outline observed on imagery.

Degradation: The decrease in display definition and detail on infrared, radar, or photographic imagery as a result of electronic transmission, photographic reproduction, or malfunctioning of the sensor.

Density: The comparative amount of silver deposited by exposure and development in a given area. It is expressed in terms of the common logarithm of the opacity (reciprocal of the transmission) of the exposed processed film.

Depression Angle (Sensor): The angle between the axis of an obliquely mounted aerial camera and the horizontal. This is the complement of the tilt angle.

Desired Mission Duration: The desired duration of continuous patroling of a ground area (not necessarily the endurance of a single aircraft).

Destroyed: Damaged to such an extent that nothing is salvageable. To insure against misuse of this term, its use must be restricted to structures which are completely leveled. In the case of bridges, all spans must be dropped and all piers must require replacement.

Detailed Photographic Coverage Plot: A graphical plot overlay keyed to a world aeronautical chart (WAC) (1:1,000,000), depicting the geographic location of mission photography.

Detailed Photographic (Imagery) Interpretation Report (DPIR or DIIR): A comprehensive analytical intelligence report written as a result of the interpretation of photography usually covering a single subject, target, or a target complex, and of a detailed nature.

Detection: To determine the location of known or unknown targets of interest by using reconnaissance techniques.

Detector: Any component or device that transduces electromagnetic radiation into a signal which can be sensed.

Diffuse Reflection: Reflection from a surface such that an incident beam of electro-magnetic energy is reflected from the surface in all directions.

Direct-View Display: A display on which the operator views film transparencies or an opaque-print image directly with or without optical aids.

Direct-View Intensification Device (DVID): A device, usually in the visible or near infrared portion of the electromagnetic spectrum, which electronically brightens the image scene.

Displacement, Image: Any dimensional change in an image reducing its usefulness as a true representation of the perspective conditions. It may result from imperfections in the optical system or in the sensitive material. Commonly used to denote the change of position of an image which occurs as the result of relief and tilt.

Displacement, Relief: The difference in the position of a point above or below the datum, with respect to the datum position of that point, owing to the perspective of an aerial photograph. Relief displacement is radial from a point on the photograph corresponding to the ground position vertically beneath the camera. In vertical photography, relief displacement is radial from the principal point of the photograph. Also called relief distortion.

Distance, Interpupillary: The distance between centers of rotation of the eyeballs of an individual.

Doppler Effect: The phenomenon evidenced by the change in the observed frequency of a sound or electromagnetic wave caused by a time rate of change in the effective length of the path of travel between the source and the point of observation.

Doppler Radar (reconnaissance/surveillance): A radar system which differentiates between fixed and moving targets by detecting the change in frequency of the reflected wave due to relative motion of target.

Downward Looking (DL): A sensor which is pointed directly below the aircraft. A downward-looking sensor produces nearly vertical imagery.

Downward-Looking Infrared (DLIR): An infrared sensor (normally a line scanner) which is pointed toward the nadir.

Downward-Looking Laser Line Scanner (DL-LLS): A laser sensor system which is pointed toward the nadir.

Drift (aerial photograph): Sometimes used to indicate a special condition of crab wherein the photographer has continued to make exposures oriented to the predetermined line of flight while the airplane has drifted with the wind. (See Crab.)

Drift (air navigation): The horizontal displacement of an aircraft, caused by the action of the wind, from the track it would have followed in still air.

Drift Angle: The angle measured in degrees between the heading of an aircraft and the ground track.

Drift Striping (radar): A wedge-shaped area appearing on the SLAR film resulting from improp drift correction.

Dwell Time:

a. Duration spent investigating and/or fixing a suspect/identified target.
b. Duration of display of a single image.

Effective Damage: That damage necessary to render a target element inoperative, unserviceable, nonproductive, or uninhabitable.

Electromagnetic Radiation: Energy emitted or reflected in the form of electromagnetic waves which include, in order of increasing wavelength, cosmic rays, gamma rays, X-rays, ultraviolet radiation, visible light, infrared radiation, microwave radiation, and radio waves.

Electromagnetic Spectrum: The total frequency range of electromagnetic radiation. (See Electromagnetic Radiation.)

Electron Beam: A continuously flowing group of electrons confined in a pencil-like flow.

Electronic Degradation: Loss of quality in an image due to electronic transmission.

Electronic Countermeasures (ECM): Electronic devices which are used to jam or mislead enemy electronic devices.

Electronic Intelligence (ELINT): The technical and intelligence information derived from foreign noncommunications electromagnetic radiations emanating from other than nuclear detonations or radioactive sources.

Electronic Reconnaissance: The detection, identification, evaluation, and location of foreign noncommunication electromagnetic radiations.

Electro-optical (E-O): Sensors or electromagnetic radiation from the near ultraviolet through the far infrared.

Elevation: Vertical distance from the datum, usually mean sea level, to a point or object on the surface of the earth. Not to be confused with altitude, which refers to points or objects above the surface of the earth.

Emissivity: The ratio of radiation emitted by a surface to the radiation emitted by a blackbody at the same temperature and under the same conditions. This may be expressed for the total radiation from all wavelengths or for the radiation from restricted bands of wavelengths. Targets are described in terms of their apparent emissivity, that is, the emissivity, as recorded by a remote sensor, where the energy emitted by a source may have been attenuated by the atmosphere or changed by the sensitivity of the sensor's detector. The following categories are generalized target descriptions (assuming a target and its background have the same emissivity):

a. Hot Target: A target that is much warmer than its background will image much brighter than its background.
b. Warm Target: A target that is warmer than its background will image lighter than its background on the film (positive).
c. Cool Target: A target that is cooler than its background will image darker than its background.
d. Cold Target: A target that is much colder than its background will image much darker than its background.

Energy, Radiant: A form of energy of electromagnetic character. All light which causes photochemical reactions is radiant energy.

Equivalent Focal Length (EFL): The distance from rear nodal to the image format in an optical system. For non-optical systems it is the ratio of the image size to object size as the EFL is to the distance from the sensor to the object. EFL is sometimes called Effective Focal Length.

Essential Elements of Information (EEI): A statement of the data regarding the enemy terrain not under friendly control, or the meteorological or hydrographic conditions, which must be collected and processed in order to enable a commander to make a sound decision as to a course of action, conduct a maneuver, avoid surprise, or formulate details of a plan of operations. The essential elements are usually enunciated in the form of questions posed for the purpose of focusing the attention and activities of all collecting agencies on the high-priority information which is needed at a particular time.

Estimate of the Situation: A logical process of reasoning by which a commander considers all the circumstances affecting the military situation and arrives at a decision as to a course of action to be taken in order to accomplish his mission.

Exposure Interval: The time required between successive photographs being taken in flight in order to provide a definite forward overlap, normally 60%. (See Overlap.) Exposure interval varies directly as the absolute altitude and inversely as the ground speed, camera focal length, and percent overlap desired.

Ferret: An aircraft, ship, or vehicle especially equipped for the detection, location, recording, and analyzing of electromagnetic radiation.

Fiducial Marks: Index marks, rigidly connected with the camera lens through the camera body, which form images on the negative. The marks are adjusted so that the intersection of lines drawn between opposite fiducial marks defines the principal point.

Field, Flatness of: The quality of a lens which affords sharpness of image both in the center and at the edges of a negative.

Field of View (FOV): The apex angle of the cone or rays passing through the front nodal point of a lens. Lenses generally are classified according to their angle of coverage, as follows:

a. Narrow-angle--less than 60°.
b. Normal-angle--60° to 75°.
c. Wide-angle--75° to 120°.
d. Super-wide-angle or ultra-wide-angle--greater than 120°.

Field Plot: An overlay, accompanying each sortie, representing the area covered on a map by that sortie.

Film (infrared): Film carrying an emulsion especially sensitive to near-infrared thru blue light. Blue light is cut out by use of a deep-red filter. Used to photograph through haze, because of the penetrating power of infrared light, and in camouflage detection to distinguish between living vegetation and dead vegetation or between vegetation and artificial green pigment.

Film (orthochromatic):

a. Literally, a film designed to record tone values corresponding to the tones of nature.
b. In practice, used to designate film sensitive to blue and green, but not to red light.

Film, Panchromatic: Film sensitive to wavelengths of 400 to 700 millimicrons, that is, to the entire visible light spectrum, including orange and red, in addition to those colors recorded by orthochromatic film.

Filter (infrared sensor): An optical material inserted in front of the detector in the infrared system; it limits the radiation to that between the specified wavelengths.

Filter (optical): A transparent material used in the optical path

of a camera lens to absorb a certain portion of the spectrum and prevent its reaching the sensitized negative.

Flight Line: A line drawn on a map or chart to represent the track of an aircraft.

F/Number: See Aperture, Relative.

Focal Length: The distance measured along the lens axis from the rear nodal point to the plane of best average definition over the entire field used in the aerial camera.

Focal Length, Back: The distance from the back or rear surface of a lens to the focal plane when the lens is focused at infinity. It is used in determining the length of camera bellows suitable for a given lens. Commonly referred to as back focus or back focal distance.

Focal Length, Calibrated: An adjusted value of the equivalent focal length, so computed as to equalize the positive and negative value of distortion over the entire field used in the aerial camera. Also stated as the distance along the lens axis from the interior perspective center to the image plane, the interior center of the perspective being selected so as to equalize the positive and negative values of lens distortion over the field. The calibrated focal length is used when determining the setting of diapositives in plotting instruments and in photogrammetric computations based on linear measurements on the negative (such as those made with a precision comparator).

Focal Length, Equivalent: The distance measured along the lens axis from the rear nodal point to the plane of best average definition over the entire field used in the aerial camera. In general usage, the term also applies to the distances from the rear nodal point to the plane of best axial definition, but in photogrammetry this meaning is rarely used and will not be understood unless the term is accompanied by a qualifying phrase.

Focal Plane (aerial photography): The plane (perpendicular to the axis of the lens) in which images of points in the object field of the lens are focused.

Foliage Penetration (FOPEN): A radar which operates at long wavelength (A Band) in order for the EM energy to penetrate the ground cover (trees) so that the return is from the ground or targets on the ground.

Format: Actual size of negative, oscilloscope, or other medium on which an image is produced.

Forward Air Controller (FAC): An airborne observer whose duties include visual observation of enemy activity and adjustment of friendly artillery fire.

Forward Edge of the Battle Area (FEBA): An imaginary line which separates friendly front line troops from "no man's land" and enemy-held territory.

Forward Looking (FL): A sensor which is pointed between the vertical position and the horizon in front of a moving airborne platform is considered a forward-looking sensor.

Forward Looking Infrared (FLIR): An infrared raster scanner which is mounted in a forward-looking position.

Forward Looking Radar (FLR): A radar which is positioned to scan an area in front of an aircraft.

Forward Motion Compensation (FMC): Compensation for the forward motion of an aircraft while photographing ground objects which is accomplished by means of a device installed in certain aerial cameras. True forward motion compensation must be introduced after the camera is oriented to the flight track of the aircraft and the camera is fully stabilized. Also called image motion compensation (IMC).

Forward Oblique: Oblique photography of the terrain ahead of the aircraft.

Frequency: The complete number of cycles per second (Hertz) existing in any form of repetitive variation, as the number of cycles per second of an alternating current or a sound wave.

Gain: The ratio of output to input of a device

Gamma (photography): A numerical measure of the extent to which a negative has been developed, indicating the proportion borne by the contrast of the negative to that of the subject on which it was exposed. The numerical figure for gamma is the tangent of the straight-line (correct exposure) portion of the curve resulting from plotting exposure against density. A gamma of 1.0 indicates a negative which has the same contrast as the subject photographed. A gamma of 1.2 indicates a negative which has greater contrast than the subject photographed.

Gap: Any space where an aerial sensor fails to meet minimum coverage requirements. This might be a space not imaged or a space where the minimum specified overlap was not obtained.

Generation: The number of reproductive steps in which a negative or positive photographic copy is separated from the original. Thus, the original negative would be the first generation; any positive made from the original negative would be the second-generation copy; and a duplicate negative made from a second-generation positive would be a third-generation copy, etc.

Geometric Fidelity: The ability of the sensor system to produce

imagery in which objects are recorded in their true geographic positions.

Gimbal: A device in a mount that permits a body to incline freely in any direction or suspends it so that it will remain level (within given limits) when the fixed portion of the mount is tipped.

Gimballed Sensor: A sensor capable of pointing in more than one direction, that is, from forward- and side-looking to down-looking and perhaps even to rearward-looking.

Glint: See Specular Reflection.

Gradation: The range of tones from the brightest highlights to the deepest shadows.

Grain (photography): One of the discrete silver particles resulting from the development of an exposed light sensitive material.

Graticule (maps and charts): A network of lines representing parallels of latitude and meridians of longitude.

Gray Bodies: Objects which emit a constant percentage of a black-body at a given temperature.

Grid: A system of lines superimposed on aerial photographs, mosaics, maps, charts, and other similar representations of the surface of the earth which permits the identification of ground locations with respect to the indicated reference system.

Grid, Universal Polar-Stereographic: A military grid system in which a grid network is applied to the polar stereographic projection of zones of the surface of the earth in the polar regions higher than 79° 30', providing an overlap of 30 minutes with the higher limits of the Universal Transverse Mercator grid.

Grid, Universal Transverse Mercator (UTM): A military grid system in which a grid network is applied to transverse mercator projections of zones on the surface of the earth extending to 80° N and S latitudes. The segments are 6 degrees of longitude wide, with 1 degree of overlap (1/2 degree each side). Authorized by the Department of the Army for all military maps to replace the World Polyconic grid.

Grid, World Polyconic: A military grid system in which a grid network is applied to polyconic projections of zones of the surface of the earth covering 9 degrees of longitude, and 1 degree of overlap between zones and extending to 72° N and S latitudes.

Ground Dimension: That area of ground portrayed in an aerial photograph, or in a series of aerial photographs. A definite ratio

exists between the negative size and the ground area relative to the focal length of lens used and the altitude at which the photography is accomplished.

Ground Range Sweep: The radar sweep representing the ground range perpendicular to the flight path.

Ground Point Tracking (GPT): A system composed of a steerable mount, computer, and a sensor and/or view finder which allows the target to be kept in view of the sensor while the aircraft is moving.

Ground Resolution: The ground size equivalent of the smallest resolvable image and its associated space, usually expressed in feet.

Ground Resolution Element (infrared): The area in the plane of the background and/or target subtended by the instantaneous field of view of the scanner. Its size is a function of depression angle, flight altitude, and instantaneous field of view.

Ground Resolution Area (radar): The approximate minimum ground area that can be resolved by the radar, and which is bound by the factors of beam width and pulse length.

Ground Speed: The actual speed of an aircraft relative to the surface of the earth.

Ground Track: The line on the ground over which an aircraft travels; also referred to as ground track line.

Ground Track Sweep (radar): The radar sweep representing the ground area parallel to the aircraft line of flight. This sweep is provided on SLAR by the motion of the aircraft.

Ground Truth: The "truth" about what is actually on the ground at the time the scene is observed or imaged.

Gyroscopic Stabilization: Equilibrium in the attitude and/or course of a ship or airborne vehicle maintained by the use of gyroscopes. Also, the maintenance (by the use of gyroscopes) of a camera in a desired attitude within an airborne vehicle.

Haze: A lack of transparency of the atmosphere, caused by the presence of foreign matter, such as dust, fog, or smoke.

Heading: The angular direction of the longitudinal axis of an aircraft measured clockwise from a reference point.

a. Compass Heading: The reading taken directly from the compass.
b. Grid Heading: The heading of an aircraft with reference to grid north.
c. Magnetic Heading: The heading of an aircraft with reference to magnetic north.

d. True Heading: The heading of an aircraft with reference to true north.

Height: Altitude above the surface of the earth. (See Altitude, Absolute.)

High Altitude: Conventionally, an altitude above 10,000 meters (33,000 feet).

High Resolution Radar (HRR): A coherent radar capable of resolving ground objects with dimensions of fifty feet or less.

Highlights: Those portions of a subject from which the greatest amounts of light are reflected.

Holiday: An unintentional omission in imagery coverage of an area.

Horizon: In general, the apparent or visible junction of earth and sky, as seen from any specific position. Also called the apparent, visible, or local horizon. A horizontal plane passing through a point of vision or a perspective center. The apparent or visible horizon approximates the true horizon only when the point of vision is very close to sea level.

Horizontal: In a plane which is at right angles to the plumb line or vertical.

Identification Friend or Foe (IFF): A common technique used is a transponder in an aircraft which, when interrogated by a friendly radar, sends a precoded signal identifying the aircraft as friendly. If the wrong signal is received at the radar station, the aircraft is considered hostile.

Identify: To establish the descriptive and/or functional name of some object or pattern detected on photography.

Image: Representation of an object on any medium by optical or electronic means.

Image Displacement: Any dimensional error in a photograph.

Image Enhancement: Any of a variety of techniques for sharpening contrast gradients by video processing.

Image Freeze: Techniques (such as storage tubes) for holding a frame of the scene stationary.

Image Interpretation: The use of systems, techniques, or processes of analyzing imagery in order to produce significant, reliable, and detailed information concerning the natural or cultural features of the area imaged and to determine or infer the factors which the observable presence, conditions, or use of these features imply.

Image Interpreter (II): An individual trained in the process of detecting, identifying, analyzing, and accurately locating with respect to a known reference, objects, and activities portrayed on imagery and of determining the tactical implications of those objects and activities. Formerly known as Photo Interpreter (PI).

Image Motion: The blur or loss of sharp detail in a photograph recording a moving image. It is caused by the movement of the camera and aircraft in flight and the inability of the camera shutter and film to record the image in a sufficiently short period of time to stop the motion.

Image Motion Compensation: (See Forward Motion Compensation).

Image Smear: A measure of the extent of target movement across the sensor during the formation of a single frame. It is related to frame time and to speed, altitude, and viewing angle.

Imagery: Images collectively. Produced electronically or by optical means on film, electronic display devices, or other media.

Index Map (photography): A map showing the location and numbers of flight strips and photographs.

Inertial Navigation System (INS): An onboard, self-contained, passive guidance system for vehicles when gyros, accelerometers, and possibly a gyro-stabilized platform satisfy guidance requirements without use of any ground-located components.

Inflight Processing: That procedure which results in a negative being produced from the exposed sensor film within an airborne vehicle.

Inflight Report: The transmission from the airborne system of information obtained both at the target and en route.

Infrared Radiation: Energy emitted or reflected in the form of electromagnetic radiation. Wavelengths of infrared radiation range from 0.70 microns to about 1,000 microns (1 millimeter) and are frequently divided, in order of increasing wavelength, into near, middle, and far infrared. (See Electromagnetic Radiation.)

Initial Photographic (Imagery) Interpretation Report (IPIR or IIIR): A first-phase photographic interpretation report presenting the results of the initial scan and analysis of new photography (imagery) in answer to the specific requirements on the highest priority targets.

Instantaneous Field of View (IFV) (infrared): The smallest solid angle resolvable by a scanner when expressed in radians. When expressed in feet, it is the projected area of the detector image on the ground and is a measure of the resolution of a scanner.

Intelligence: Knowledge achieved by logical analysis and integration of available data concerning one or more aspects of foreign nations and areas and immediately or potentially significant to planning.

Intelligence, Basic: That factual intelligence which results from the collection of encyclopedic information of more or less permanent or static nature and general interest which, as a result of evaluation and interpretation, is determined to be the best available.

Intelligence Data Base: An aggregation of finished or initially processed intelligence data, in any form or format, and from any source, which can be exploited to provide information to augment specific analysis and validate decisions.

Intelligence, Current: That limited information or intelligence of all types and forms, of immediate interest and value to operating or policy staffs, which is used by them usually without the delays incident to complete evaluation or interpretation.

Intelligence, Estimate: An appraisal of the element of intelligence relating to a specific situation or condition which is normally based upon capabilities and potentialities.

Intelligence Requirements: Any subject about which there is a need for the collection of information or the production of intelligence.

Intelligence, Strategic: Knowledge pertaining to the capabilities, vulnerabilities, and probable courses of action of foreign nations, needed in the planning and execution of national security measures in time of peace and in the conduct of military operations in time of war.

Intelligence, Technical: Intelligence concerning technological developments which have advanced to the point of having practical application for war purposes. It includes all steps in development which follow the initial application of a principle or theory for the purpose of waging war.

Intensity (light): The quantity of light emitted or reflected from a given source.

Intervalometer: A timing device for automatically operating the shutter of a camera at regular intervals.

Key, Image Interpretation: A device or other reference material designed to aid image interpreters in the rapid, accurate identification of an object from the study of its image.

Kilometer: A measure of length in the metric system equivalent to 0.62137 or approximately 5/8 of a statute mile.

Knot: A unit of speed, equivalent to 1 nautical mile (approximately 6,076.1 feet or 1.15 statute miles) per hour.

Laser: Light Amplification by Stimulated Emission of Radiation (a technique for generating a highly concentrated, coherent beam of electro-optical energy).

Laser Line Scanner (LLS): A laser used to scan the terrain directly below the aircraft.

Lateral Coverage: The ground distance represented by and included in aerial imagery as measured on a line perpendicular to the line of flight.

Latitude:

a. (Exposure). The quality of a film or plate indicating the variation in exposure which can be tolerated without detriment to image quality.

b. (Development). Allowable variation in the recommended development time without appreciable difference in contrast.

c. (Geographic). Angular distance north or south of the Equator measured along a meridian.

Lens Assembly: A complete unit composed of lens elements, diaphragm, and lens barrel.

Lens Element: One lens of a complex lens system. In a photographic lens, the terms front and rear elements are often used.

Line of Communication (LOC): A supply route or communication link between two points, for example, roads, railroads, trails, waterways, and telephone/telegraph lines.

Littoral Vegetation: Vegetation typical of shorelines.

Line of Site (LOS): Line of sight or centerline of the three-dimensional field of view of a sensor.

Locate:

a. To find or establish the site of a known installation on the actual aerial photograph.

b. To find or show the position on a map of an installation or site seen on imagery; after the installation or site has been seen, the image interpreter may locate it with regard to geographic or UTM coordinates.

Long Range Navigation (LORAN): A hyperbolic navigation system using low-frequency radio waves (100 KC).

Low-Light-Level Television (LLLTV): A television with an image orthicon or other image intensifier device; used for night reconnaissance.

Luminosity: The average brightness of the displayed image.

Mach Number: Ratio of the velocity of a body to that of sound in the medium being considered; 762 mph at sea level is considered Mach 1.

Magazine (photographic): A container for protecting and holding film while the camera is in operation. It is usually detachable from the camera so that a new magazine may be loaded without removing the camera from its mount.

Magnetic Declination: The angle between true (geometric) north and magnetic north (direction of the compass needle). The magnetic declination varies for different places and changes continuously with respect to time.

Magnification (optics): The ratio of the size of an image to the size of the object; normally the ratio of a linear quantity in the image to a corresponding linear quantity in the object.

Map: A representation on a plane surface, at an established scale, of the physical features (natural, artificial, or both) of a part or all of the surface of the earth with the means of orientation indicated. Also, similar representation of the heavenly bodies. A map may emphasize, generalize, or omit the representation of certain features to satisfy specific requirements. Frequently the word "map" is preceded by an adjective which explains what type of information the map is designed primarily to present.

Map, Operations: A map showing the location and strength of friendly forces involved in an operation. It may indicate predicted movements and location of enemy forces.

Map, Planimetric: A map which represents only the horizontal positions of represented features; distinguished from a topographic map by the omission of relief in measurable form. The natural features usually shown on a planimetric map include rivers, lakes, seas, mountains, valleys, marshes, plains, forests, prairies and deserts. The cultural features include cities, farms, transportation routes, public utility facilities, and political and private boundaries. A planimetric map intended for special use may present only those features which are essential for its purpose.

Map, Scale: The relationship of the size of the maps to the size of the ground which it represents.

a. Large Scale: Maps having a scale of 1/75,000 or larger.
b. Medium Scale: Maps having a scale from 1/75,000 exclusive, to 1/600,000, inclusive.
c. Small Scale: Maps having a scale smaller than 1/600,000.

Map, Topographic: A map which presents relief or the vertical position of features, as well as their horizontal positions, in measurable form.

Masking Angle: The average depression angle beyond which the target is unobscured by terrain or vegetation.

Mensuration: Measurement of images on film.

Microwave: A very short electromagnetic wave; any circuitry-produced wave shorter than about 100 centimeters in wavelength.

Military Grid Reference System: A system which uses a standard-scaled grid square, based on a point of origin on a map projection of the surface of the earth in an accurate and consistent manner to permit either position referencing or the computation of direction and distance between grid positions.

Milliradian (infrared): One thousandth of a radian. It is approximately the angle subtended by an arc 1 foot in length at 1,000 feet and is the basic factor in determining ground resolution of a given system.

Mission:
A mission denotes the following:
a. The objective, the task together with the purpose, which clearly indicates the action to be taken and the reason therefor.
b. In common usage, especially when applied to lower military units, a duty assigned to an individual or unit; a task.
c. The dispatching of one or more aircraft to accomplish one particular task.

Mission Duration: The maximum time that a mission is maintained. In the case of LOC patrol, it is the time that traffic is to be monitored, and a relay of sorties may be required to complete the mission.

Mode: The various ranges of radar coverage and the corresponding presentation on the SLAR film.

Modulation Transfer Function (MTF): This is a variable which describes the relationship among scene illumination, resolution, and contrast. It is usually expressed in terms of percent modulation as a function of spatial frequency (or spacing of a repetitive pattern) for a particular luminance condition.

Mosaic: An assembly of overlapping aerial photographs which have been matched to form a continuous photographic representation of a portion of the surface of a planet or satellite.
a. Controlled. A mosaic made of aerial photographs corrected for scale, rectified, and laid to ground control to provide an accurate representation of distances and direction.
b. Semi-controlled. A mosaic composed of uncorrected vertical aerial photographs laid to a limited ground control.

c. Uncontrolled. A mosaic composed of uncorrected prints, the detail of which has been matched from print to print without ground control or other orientation.

Mosaic, Strip: A mosaic consisting of one strip of aerial photographs taken on a single flight.

Mount, Aerial Camera: A device which supports a camera in an aircraft for vertical and oblique photography. A vertical mount may permit the camera to be rotated about a vertical axis and to be tilted in any direction for leveling.

Moving Target Indicator (MTI): Any radar that indicates that an object has changed position between sweeps.

Multicamera Installation (or Station): Three or more cameras mounted so as to provide a small amount of sidelap between two adjacent cameras for the purpose of providing extended lateral coverage with long-focal-length, large-scale cameras. Installations with an odd number of cameras include a vertical camera in the center; those with an even number of cameras fan out from a split-vertical installation. Multicameras are designated as left or right on the basis of the ground being photographed with respect to the line of flight, not necessarily the position of the camera in the aircraft.

Multisensor: A term pertaining to an integrated system designed to record imagery from different portions of the electromagnetic spectrum in support of all-weather data acquisition roles.

Multisensor Operator (MSO): An airborne operator trained to operate more than one sensor.

Multispectral Imagery: That imagery which is produced as a result of combining two or more types of sensings on a single image format, thus producing a compound target image such as infrared (camouflage detection) film.

Nadir: That point on the ground directly beneath the observer or camera. On a photograph the point at which a vertical line through the perspective center of the camera lens pierces the plane of the photography. Also referred to as the "nadir point."

Nautical Mile: 6,076.12 feet or 1852 meters.

Near-Real-Time (NRT): A mode of operation in reconnaissance missions in which the rate of display of sensor images parallels the rate of acquisition of sensor data. However, the display event lags the acquisition event by a small constant interval.

Negative:

a. A photographic image on film, plate, or paper, in which the tones are reversed.

b. A film, plate, or paper containing such a reversed image.

Night Observation Device (NOD): A device that utilizes an image intensifier to permit the viewer to see at low-light levels.

Noise: An unwanted receiver response, other than another signal (interference). Noise may be audible in voice communication equipment, or visible in equipment such as radar. In the latter case it is also known as snow.

Noise Equivalent Temperature (NET)(infrared): The minimum increment in the temperature of a blackbody at the input of the infrared system that yields a signal-to-noise ratio of unity at the output of the scanner. This term usually is used synonymously with thermal (temperature) sensitivity and thermal resolution.

Nomograph (Nomogram): A graph used as a handy calculator for the solution of specific problems.

Order of Battle: The identification, strength, command structure, and disposition of the personnel, units, and equipment of any military force.

Orientation: Direction or arrangement with respect to other detail. The direction in which a photograph is turned with respect to observer, map, etc. A single photo is best oriented for study when turned so that the shadows are cast toward the observer.

Orientation, Exterior: A set of quantities which fixes the position of the camera station and the angular orientation of the photograph. Such a set consists of three elements of position and two elements of angular orientation. The position is usually expressed in terms of three rectangular coordinate distances --x, y, and z. The elements of angular orientation are essentially the tilt of the photograph perpendicular and the azimuth of the principal plane.

Orientation, Interior: The establishment of the principal distance and the position of the principal point of a photograph with respect to the fiducial marks of the camera.

Orientation, Relative: The determination (analytically or with a photogrammetric instrument) of the position and altitude of one of a pair of overlapping photographs with respect to another photograph.

Overdevelopment: The result of allowing film or paper to remain in the developer too long, resulting in excessive contrast or fog.

Overexposure: The result of too much light being allowed to act on a light-sensitive material, with either too great a lens aperture or too slow a shutter speed or both. Results in excessive image density.

Overlap: The amount by which one photograph includes the area covered by another photograph, usually expressed as a percentage. The overlap between successive aerial photographs on a flight line is called forward overlap. The overlap between photographs on adjacent parallel flight lines is called sidelap.

Overlay: A printing or drawing on a transparent or translucent medium at the same scale as a map, chart, etc., to show details not appearing, or requiring special emphasis on the original.

Panorama: A photograph of a wide expanse of terrain, normally oblique photography, generally taken on or near the surface of the earth; more often a series of adjoining or overlapping photographs.

Panoramic Aerial Camera: An aerial camera which, through a system of moving optics, scans a wide area of the terrain usually from horizon to horizon. The camera may be mounted vertically or obliquely within the aircraft to scan across or along the line of flight.

Passive Sensor: A sensor which collects radiation emitted from another source, such as daylight and infrared energy.

Pattern: In a photo image, the regularity and characteristic placement of tones or textures. Some descriptive adjectives for patterns are regular, irregular, random, concentric, radial, and rectangular.

Petroleum, Oil, and Lubricant (POL): Facilities for extraction, processing, or storage of petroleum products.

Phase Histories (SLAR): Frequency history of return signals from each point on the ground; peculiar to a coherent system.

Phosphor: A substance that emits light when excited by an electron beam.

Photogrammetry: The science or art of obtaining reliable measurements by means of photography.

Photographic Scale: The relationship of a distance measured on a photograph to the corresponding ground distance, expressed as a ratio or as a representative fraction (1/10,000).

Photo Interpreter (PI): Old terminology for an Image Interpreter.

Photomap: A single photo, composite, or mosaic showing coordinates and adequate marginal information; normally reproduced in quantity.

Pilot's Trace: An annotated map or overlay compiled with the assistance of the pilot of a reconnaissance mission. It contains information such as ground track of the reconnaissance

aircraft, sensor designation, locations of sensor operation, indicated altitudes at specified checkpoints, recorded times at specified checkpoints, and estimated cloud cover observed along the flight line.

Pitch: Rotation about the transverse axis of the vehicle/camera system. (Commonly referred to as tip.)

Plan Position Indicator (PPI): A radar indicator with a rotating time base line which provides a map-like presentation of the terrain below the aircraft.

Plane, Focal: The plane perpendicular to the axis of the lens in which images of points in the object field of the lens are focused. Occupied by the film or plate during exposure.

Point, Critical:

a. A key geographical point or position important to the success of an operation.
b. In point of time, a crisis or a turning point in an operation.
c. A selected point along a line of march, used for reference in giving instructions.
d. A point where there is a change of direction or change in slope in a ridge or stream.

Point Reconnaissance: A vertical aerial photograph or other image of a predetermined point. A type of special cover to obtain significant detail of small areas or objects, for example, spot photography.

Point Source (infrared): Any source whose size is smaller than the area subtended by the instantaneous field of view of the scanner at that point.

Position: The location of a point with respect to a reference system, such as a geodetic datum. The coordinates which define such a location. The place occupied by a point on the surface of the earth. Often construed as horizontal position when elevations are considered separately.

Positive:

a. An image having approximately the same rendition of light and shade as the original subject.
b. A film, plate, or paper containing such an image.

Possible: A term used in imagery interpretation to qualify a statement when, in the opinion of the interpreter, the available evidence is sufficient to warrant making the statement, but not strong enough to justify assumption as factual.

Post-Strike Reconnaissance: Missions designed to gather information used to measure the results of a strike.

Preplanned Request (reconnaissance): A request by a ground commander for reconnaissance of a target or in support of a maneuver which can be anticipated sufficiently in advance to allow detailed mission coordination and planning.

Prestrike Reconnaissance: Missions flown for the purpose of obtaining complete information about known targets for use by the strike force.

Principal, Point: The foot of the perpendicular from the interior perspective center to the plane of the photograph, that is, the foot of the photograph perpendicular.

Print: A photographic copy made by projection or contact printing from a photographic negative or from a transparent drawing, as in blueprinting.

Priority System for Requests for Tactical Reconnaissance:

Priority I: Takes precedence over all other requests except previously assigned Priority I's. The results of these requests are of paramount importance to the immediate battle situation or objective.

Priority II: The results of these requirements are in support of the general battle situation and will be accomplished as soon as possible after Priority I. These are requests to gain current battle information.

Priority III: The results of these requests update the intelligence data base but do not affect the immediate battle situation.

Probable: A term used to qualify a statement made under conditions wherein the available evidence compels that the statement be assumed as true until there is further evidence in confirmation or denial. The term is stronger than "possible."

Projection Viewer (Projection-View-Display): An image display in which film is transilluminated and is projected on a display surface other than the film. The operator views the display screen rather than the film.

Pulse Length: The length of time a radar transmitter is energized during each pulse. Also called pulse duration and pulse width.

Pulse Repetition Frequency (PRF): In radar, the number of pulses that occur each second. Not to be confused with transmission frequency which is determined by the number of radio waves in each second.

Radar (Radio Detection and Ranging): The science of locating and/or identifying distant objects by means of radio techniques. Radar depends on two processes: one, the reflection of radio waves by material bodies, and the other, the use of short pulses of high-frequency energy to make possible the accurate measurement of distance.

Radar Beam: A directional concentration of propagating radio energy; antenna beam.

Radar Clutter: Unwanted signals, echoes, or images on the face of the display tube which interfere with observation of desired signals.

Radar, Echo: The reflected radio frequency energy from objects adjacent to the radar transmitter.

Radar, High-Resolution (HRR): See Side Looking Airborne Radar.

Radar Horizon: The line at which direct radar rays are tangential to the surface of the earth.

Radar Imagery: Imagery produced by recording radar waves reflected from a given target surface.

Radar Map: A term sometimes used to describe the recording of a side-looking, high-resolution radar.

Radar Reconnaissance: Reconnaissance by means of radar to determine the location, disposition, and strength of enemy forces and to determine the nature of terrain.

Radar Resolution:

a. Range Resolution: The minimum size of objects and the space between them that will show as separate returns on the radarscope when one object is farther than the other in range.
b. Track Resolution (Azimuth): The minimum size of objects and the space between them that will show when the targets are aligned parallel to the flight path.

Radar Return: The radar counterpart of a ground object as produced on the radar record; radar image.

Radargrammetry: The science or art of obtaining reliable measurements from radar presentations.

Radio Frequency (RF): Frequency of radio signals in the radio region of the electromagnetic spectrum.

Range Finder: An optical instrument for measuring the distance to the subject.

Range-Gating: A technique for reducing the laser system display noise produced by backscatter from airborne particulate matter. Signals returning sooner than is possible by reflection from the closest ground point are not accepted ("gated-out").

Range, Ground (GR): The horizontal distance measured along a sweep line from a ground point directly beneath the aircraft to an object on the ground.

Range, Slant (SR): The distance measured along the line of sight from the aircraft to an object on the ground.

Raster: A two-dimensional scan presentation on a cathode ray tube.

Reading (Photographic or Image): The simple identification or description of the content of images without analysis of their meaning (Contrasted with Interpretation.)

Real Time: The absence of delay in acquisition, transmission, and reception of data.

Reconnaissance: A mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy; or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area.

Reflection: The return of light or electronic signals from any surface.

Refraction: The bending of light rays when light passes from one transparent medium into another having a different index of refraction. The angle of refraction is the angle the refracted ray makes with the line perpendicular to the surface separating the two media.

Relief: Variation in elevations on the surface of the earth.

Representative Fraction (R.F.): The relationship between map or image distance and ground distance, expressed as a fraction (1/25,000) or often as a ratio (1:25,000) (1 unit on map = 25,000 units on ground). Also called scale.

Requirements (intelligence): A statement of specific need for the production of intelligence or the collection of intelligence information, and an authorized demand on a producer or collector to satisfy such need.

Resolution (photographic): The ability of the entire photographic system, including lens, exposure, processing, and other factors, to render a sharply defined image. It is expressed in terms of lines per millimeter recorded by a particular film under specified conditions. (See Radar Resolution and Infrared Resolution.)

Resolution Square (radar): The rectangular area on the ground defined by range resolution and track resolution. (See Radar Resolution.)

Return: Signal reflected by an object back to the signal sensing device.

Reversal (IR): A dark-to-bright or a bright-to-dark shift in the displayed brightness relationship of two objects as a result of

temperature changes of the objects or of sensing another part of the infrared spectrum in which the relative emissivities of the objects are reversed.

Roll: The rotation of an aircraft about its longitudinal axis.

Route Reconnaissance: Reconnoitering of a line of communication (LOC) for military purposes, often by an aerial vehicle.

Run (reconnaissance): The line followed by an aircraft while operating an aerial sensor or camera.

Scale: The ratio of a distance measured on a map, photograph, or mosaic to the corresponding distance on the ground. Scales of aerial reconnaissance photography are classified as follows:

a.	Very large	1:6,000 and larger
b.	Large	1:6,000 to 1:12,000
c.	Medium	1:12,000 to 1:26,000
d.	Small	1:26,000 and smaller

Scale Reciprocal: The reciprocal of the representative fraction (RF): for example, if the RF is 1/10,000, then the scale reciprocal is 10,000.

Scan Angle (infrared): The total angle or field of view that the scanner subtends (measured normal to the line of flight). This angle is bisected by the nadir and is usually within the limits of ± 30 to ± 70 degrees from the nadir (that is, between 60 and 140 degrees total angle.)

Scan Line (infrared): The segment of the imagery produced during one sweep of the modulated light source across the recording film. It represents the area of the object plane subtended during one lateral scan by the system.

Scanner (infrared): An optical-mechanical image-forming device that receives electromagnetic radiation from objects during successive scans across the plane of the object. It converts the radiation to electrical signals that subsequently modulate the output of light from a recording device to form a photographic image of the relative levels of radiation in the scanned scene.

Scintillation (TV): Random occurrence of many noise-produced spots on successive image frames.

Search (image interpretation): A comprehensive examination of all photography (imagery) covering a specific type of target(s) within a designated geographic area and time frame.

Search Mission: An aerial reconnaissance by one or more aircraft dispatched to locate an object or objects known or suspected to be in a specific area.

Sensor (artificial): A technical means to extend man's natural senses; an equipment which detects and indicates terrain configuration, the presence of military targets, and other natural and man-made objects and activities by means of energy emitted or reflected by such targets or objects. The energy may be electromagnetic, chemical, biological, thermal, or mechanical, including sound, blast, and earth vibration.

Shadow (radar): The area of no return on the radar photo resulting when an intervening object prevents radar energy from striking that area.

Shadows: Obscurity within a part of space from which rays from a source of light are cut off by an interposed opaque body such as a building or a radio tower.

Shape: Physical configuration or outline.

Shutter: The mechanism of a camera which, when set in motion, permits light to reach the sensitized surface of the film or plate for a predetermined length of time.

Shutter, Between the Lens: A shutter located between the lens elements of a camera; usually consisting of thin metal leaves which open and close or revolve to make the exposure.

Shutter, Focal-Plane: A shutter located near the focal plane; usually consisting of a curtain with a slot which is pulled across the focal plane to make the exposure.

Shutter, Louver: A shutter consisting of a number of thin metal strips of louvers which operate like a venetian blind to make the exposure; usually located just in front of or just behind the lens.

Side Looking Airborne Radar (SLAR): See Side Looking Radar

Side Looking Radar (SLR): An airborne radar that produces an image of a portion of the surface of the earth by means of one or more antennas viewing at approximately right angles to the longitudinal axis of the aircraft. Sometimes referred to as Side Looking Airborne Radar (SLAR).

Site:

a. The position of an object in relation to its environment.
b. The place actually occupied, previously occupied, or to be occupied by a target.

Size: This parameter may refer to the area of a flat target, the volume of a three-dimensional target, or the extent of a group of targets, such as a truck convoy.

Slant Range Markers: Precisely timed electronically produced indications on a sweep line which are used for slant range measuring.

Slew Rate: This is the maximum rate at which the FOV can be moved in a controllable pointing sensor system.

Slope: Roughness of terrain usually given in a percentage; the change in elevation divided by the change in horizontal distance.

Snow: The colloquial term for the random pattern of white dots present on a television screen under weak or zero-signal conditions.

Solar Angle (Sun Altitude): Usually expressed in degrees referring to the angular position of the sun above the horizon. If the solar angle is less than 30 degrees, deep shadows will be encountered in aerial photography.

Sortie (air): An operational flight by one aircraft.

Sortie Plot: An overlay representing the area on a map covered by imagery taken during one sortie.

Southeast Asia (SEA): That portion of Asia made up primarily of Burma, Cambodia, Indonesia, Laos, Malaysia, North Vietnam, Philippines, Singapore, South Vietnam, and Thailand.

Specific Intelligence Collection Requirement (SICR): An identified gap in intelligence holdings that may be satisfied only by collection action, and which has been validated by the appropriate requirements control authority.

Specific Search: Reconnaissance of a limited number of points for specific information.

Specular Reflection: The type of reflection characteristic of a highly polished plane surface from which all rays are reflected at an angle equal to the angle of incidence. Also called Glint.

Speed, Emulsion (photography): A measure of the sensitivity of the emulsion. It determines the exposure required to produce the desired image.

Spoil: Unprocessed waste, such as refuse, earth, or rock debris, resulting from excavating or dredging.

Spot Size: The size of the diamater of the electron beam on the cathode-ray tube.

Squint Angle: An angle slightly less than perpendicular at which the SLAR looks outward from the side of the aircraft.

Statute Mile: 5280 feet or 1609.34 meters.

Stereographic Coverage: Photographic coverage with overlapping aerial photographs to provide a three-dimensional presentation of the picture; 60-percent overlap is considered normal and 53-percent is generally regarded as the minimum.

Stereoscopic Image: That mental impression of a three-dimensional object which results from stereoscopic vision.

Stereoscopic Vision (Stereo Vision): That application of binocular vision which enables the observer to view an object simultaneously from two different perspectives (as two photographs taken from different camera stations) to obtain the mental impression of a three-dimensional model.

Strike: A concerted air attack on a single objective.

Strike Control and Reconnaissance (SCAR): This term is used in conjunction with aircraft or aircrew to designate a mission which includes visual reconnaissance, strike control, and artillery fire adjustment.

Strike Photography: Photography taken during an air attack.

Strip, Reconnaissance: A series of overlapping aerial photographs which, when joined together, will provide a continuous picture of the area photographed. A reconnaissance strip is generally used in studying a long narrow piece of terrain such as a river or a road.

Structural Damage: Destruction, displacement, severance, or distortion of structural member (trusses, beams, and columns) to such a degree of severity that the damaged member cannot be repaired but must be removed and replaced. The latter condition is considered to exist if the above types of damage to structural members can be identified by the image interpreter.

Superficial Damage: Damage which can be repaired without affecting the main structure and without necessitating replacement of main frame members.

Supplementary Photographic (Imagery) Report (SUPIR or SUIIR): A supplemental photographic (image) interpretation report to the IPIR (IIIR).

Surface-to-Air Missile (SAM): A type of missile which is used against hostile aircraft from ground sites.

Surface-to-Surface Missile (SSM): A type of missile which is used against ground or sea targets from ground sites.

Sweep, Ground Range (SLAR): The sweep deflection on a CRT representing ground range direction or direction perpendicular to the radar antenna.

Sweep, Ground Track (SLAR): A term describing the recording of the succeeding ground range sweeps by the movement of the film over the ground range sweep lines at a rate proportional to aircraft speed.

Swing: The rotation of a photograph in its own plane around the photograph perpendicular. Also, the angle at the principal point of a photograph measured clockwise from the positive y-axis to the principal line at the nadir point.

Tactical Aerial Reconnaissance: Airborne data collection and the subsequent processing, interpretation, and distribution of derived intelligence concerning terrain, weather, the enemy's force structure, movement, strength, disposition, capability, actual or potential lines of communication, and other enemy resources that could affect the tactical situation.

Tactical Air Navigation (TACAN): A navigation system in which an aircraft interrogates a TACAN station. The station sends magnetic azimuth, station identification, and distance to the inquiring aircraft.

Target (intelligence): A specified installation, object, activity, or geographic area of intelligence interest.

Target Acquisition: The detection, identification, and location of a target in sufficient detail to permit the effective employment of weapons.

Target Analysis: An examination of potential targets to determine military importance, priority of attack, and weapons required to obtain a desired level of damage or casualties.

Target Area: The environs of a target which might reasonably encompass associated activity.

Target Brief: Consolidated reference, including photo, map and collateral materials, on a given target for use by the image interpreter preparing a description of that target as seen on a particular mission for a first or second phase report.

Target Complex: A geographically integrated series of target concentrations.

Target Concentration: A grouping of geographically proximate targets.

Target Coverage: Indication of the partial or complete portrayal of a target on photography.

Tactical Information Processing and Interpretation (TIPI): An Air Force mobile facility to process, interpret, store, and retrieve intelligence information derived from aerial reconnaissance, but not limited to that source.

Target Lifetime:

a. Area Search: The time span within which a target is vulnerable to location and strike.

b. Close Air Support: The duration of time between the call for support and the attack for which the value of the strike exceeds 10 percent.

c. LOC Patrol: The duration of time that a specific target is on the LOC being patrolled.

Target Pinpoint: A target which is a particular object of destruction requiring the accurate placement of bombs.

Target Signature: A feature or pattern of features (size, shape, spectral response, etc.) that can be sensed and utilized in the detection and recognition of a target.

Target System: A group of targets which are so related that their destruction will produce some particular effect desired by the attacker.

Target System, Component: A set of targets belonging to one or more groups of industries and basic utilities required to produce component parts of an end product (such as aircraft engines), or one type of a series of interrelated commodities (such as aviation gasoline).

Television: The transmission and reception of visual images by electrical means, usually radio, for instantaneous viewing.

Television Imagery: Imagery acquired by a television camera and recorded or transmitted electronically.

Terrain: An area of ground considered as to its extent and topography.

Texture (photography): In a photo image, the frequency of change and arrangement of tones. Some descriptive adjectives for textures are fine, medium, or coarse, and stippled or mottled.

Texture (radar): The mottled or spotted appearance of a group of radar returns within an area.

Thermal Imagery (infrared): Imagery produced by measuring and recording electronically the thermal radiation of objects.

Thermal Radiation (infrared): The continual radiation of energy from the surface of all objects above absolute zero.

Tilt, Axis of: The line through the perspective center perpendicular to the principal plane. The term is arbitrarily restricted to this definition. The axis of tilt could be any one of several lines in space, for example, the isometric parallel or the ground line; but the present definition is the only one which permits the concept of tilting the photograph without upsetting the positional elements or exterior orientation.

Time, Greenwich Mean: Mean solar time of the meridian of Greenwich used by most navigators and adopted as the prime basis of standard time throughout the world. Also called Zulu time.

Time Over Target (TOT): That time when an aerospace vehicle is positioned over a predetermined point on the ground.

Time, Standard Civil: Mean solar time based upon the transit of the sun over a certain specified meridian, called the time meridian and adopted for use over a considerable area. With a few exceptions, standard time is based upon some meridian which differs by a multiple of 15 degrees from the meridian of Greenwich. Civil (local) time begins at midnight.

Title Block: A space on a mosaic, map, or plan devoted to identification, reference, and scale information.

Tone: Each distinguishable shade variation from black to white.

Topography: Features of the surface of the earth considered collectively as to form. A single feature (such as a mountain or valley) is called a topographic feature. Topography is subdivided into hypsography (relief features), hydrography (water and drainage features), and culture (man-made features).

Track: The actual path of an aircraft above, or a ship on, the surface of the earth. The course is the path which is planned; the track is the path which is actually taken.

Transparency: A photographic print made on a transparent base (such as film) and viewed by transmitted light.

True Horizon: The plane perpendicular to the vertical axis and passing through the rear nodal point of the lens.

Ultraviolet Imagery: That imagery produced as a result of sensing ultraviolet radiations emitted from a given target surface in the ultraviolet portion of the electromagnetic spectrum (10 to 400 nanometers).

Underdevelopment (photography): Insufficient development, due to developing either for too short a time or in a weakened developer, or occasionally, at too low a temperature.

Underexposure: The result of insufficient light being allowed to pass through the lens to produce all the tones of an image, or of sufficient light being allowed to pass for too short a period of time.

Unidentified (U/I): Evidence is insufficient to permit designation of the function, type, or name of a target to the degree needed in the context of the intelligence requirements.

Universal Transverse Mercator (UTM) Grid: A grid system for locating and referencing points. The system consists of two sets of parallel lines intersecting at right angles to form a series of squares.

Velocity/Height (V/H) Ratio: Aircraft velocity divided by altitude (height). A ratio which represents the apparent angular motion of ground objects at the nadir relative to the aircraft.

Video (communications): Those electrical signals which carry image information.

Video Gap: The appearance of an area of no radar return running parallel to and directly below the flight path of the aircraft.

Viewfinder:

a. A camera attachment which shows on a viewing lens the image thrown by the camera lens on the photographic plate.
b. An aerial sighting instrument with a grid of crosshairs on a ground-glass screen, usually mounted behind the camera.

Vignette:

a. The interference, by the lens mounting or other obstruction, which causes a reduction in the effective diaphragm area.
b. A process of regulating the distribution of light which reaches the print in such a way that the image obtained fades out toward the edges.

Vignetting Filter: A filter which gradually decreases in density from the center toward the edges. It is used in certain cases, in photography or printing processes to produce a photograph of uniform density.

Visual Reconnaissance (VR): Flight regime in which visual contact with the ground is maintained for the purpose of obtaining information about ground-based targets and activities.

Wavelength: The distance a wave of energy (a-c, sound, r-f) travels in the time it takes for one cycle of this wave to be completed. This is the same as the distance from a particular point on the wave to the corresponding point on the next wave. For radio waves travelling in air, wavelength in meters is found by dividing the speed at which the r-f is travelling (299,792,500 meters per second) by the frequency of the wave in cycles per second.

Wedge (optics): A refracting prism of very small deviation, such as those used in the eyepieces of some stereoscopes.

White Cold: A mode of sensor display operation in which the "cooler" objects and areas in the FOV image are whiter than the "hotter" objects and areas.

White Hot: A mode of sensor display operation in which the "hotter" objects and areas in the FOV image are whiter than the "cooler" objects and areas.

Windows (infrared): A piece of optical material used with a system to permit the passage of infrared radiation. The word "window" also is used to denote a region of the electromagnetic spectrum in which radiation is only slightly attenuated as it propagates through the atmosphere.

Yaw: An angular displacement about the vertical axis of an aircraft.

Zenith: That point in the sky directly above the observer (opposite of nadir).

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